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THE ENGINEERING MAGAZINE OF THE OIL AND GAS INDUSTRY

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Next Month

The first of a new Series of Articles

..by..

Lester C. Uren

Professor of Petroleum Engineering University of California

•

Professor Uren spent some time in Europe last summer, visiting the important oil fields and refineries in the vicinity of Grozny and Baku, in Russia. Going as an invited guest of the Oil Trust of the U.S.S.R., Professor Uren was given a rare opportunity for observing recent oil industry developments and petroleum production research in Russia. He has prepared two articles based on his Russian observations, the first of which will appear in the December issue. While in Europe he also visited the Pechelbronn oil mines in France, where he was permitted to go underground and get a general view of their operations. His observations there will also be the subject of an interesting article on oil mining.

Professor Uren's acute observational powers, his keen analysis of methods and practices, and his constant touch with the technical progress in the oil industry, will render these articles of especial interest to our readers.

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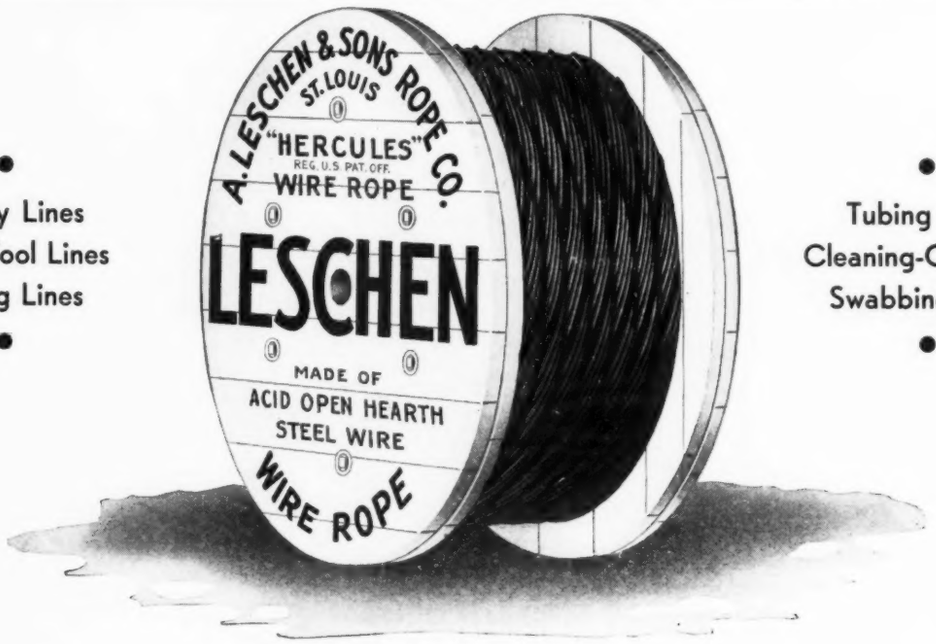

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The Course of Oil

By K. C. SCLATER

Address Inspires Confidence

Mr. Ickes' address at the annual meeting of the American Petroleum Institute at Chicago last month leaves one convinced that the Federal Oil Administrator has a broad and firm grasp of the shortcomings of the oil industry and the problems confronting it. Everyone was impressed by his rare understanding and sympathetic attitude. He has instilled a new note of confidence among leaders in the industry by his sincere and emphatic declaration of his desire to rid the oil industry of its ills and see it safely back on its feet.

Efforts of the Oil Administrator in this direction show a determination to get at the facts. Idle complaints or complaints unsupported by relevant substantiating evidence find a deaf ear. In the matter of price-fixing, the issue has been left open to consider any evidence that may be submitted by producers and refiners in protest or in support of any measure before it is put into effect.

In no uncertain terms he outlined the policy to be pursued by the Administration in bringing supply and demand into balance. He stated that price-fixing, powerful and drastic remedy that it is, was of no vail unless production was kept within bounds. Unless restricted to the figures permitted by his last order, Mr. Ickes intends to exercise the extraordinary powers given by the oil code. This means that the quietus will be put on overproduction by states on and after December 1, if the trouble has not been eradicated by that date. On this point there is no equivocation.

Price-Fixing and Cost Data

Mutterings have been heard over the questionnaire sent out by the Oil Administration calling for certain information concerning production, transportation and refining costs and other pertinent operating data. Producers and refiners opposing or supporting the proposed schedule of minimum prices, which it is planned to put into effect December 1, are required to fill out the questionnaire. This information is expected to throw some light on actual operating costs and aid in forming a sound working basis upon which the justice or injustice of the code provisions on price-fixing can be determined.

On looking over the questionnaire, one is forced to the conclusion that the information requested therein includes nothing but what any prudent operator, whether large or small, should maintain for the efficient conduct of his business. Nevertheless, it is reported that many companies have not readily available all the data requested.

"That some in the petroleum industry have no conception of what their actual costs are was made painfully evident by some of the statements made at the hearings on the several codes proposed." This observation was made by Wirt Franklin, chairman of the Planning and Co-ordinating Committee, in his address at Chicago before the members of the American Petroleum Institute. There are probably good grounds for this indictment. Possibly it is true that there is an appalling lack of data in the oil industry pertaining to operating costs. Perhaps many mistakes of the past might have been avoided had good cost records been available. If the Oil Administration succeeds in impressing upon all operators the need for adequate operating cost records it will have done the oil industry a great service.

One Well Defies Curtailment

A classic example of the far-reaching damage one wild or mismanaged well can cause comes to observation in the Conroe field, Texas. In this field there is a cratered producing well the production from which cannot be controlled. The well is producing some 6000 barrels of oil daily and enormous volumes of gas are being dissipated while all other wells in the field are strictly prorated and not permitted to produce but about 125 barrels daily. Apparently there was nothing the Railroad Commission could do about it.

One company with large interests in the field, fully aroused over the devastating effect of this well on the life of the field, not to mention the menace of the crater itself, has undertaken to kill the well. This company has bought the well from the owners and is now engaged in preparations to drill an inclined hole, the inclination so directed as to tap the well near where it penetrates the producing horizon. At the surface the inclined hole will be started within a few hundred feet of the cratered well and drilled at the required angle by means of oriented whipstocks. It is conceded to be a hazardous undertaking and elaborate preparations are being made to guard against failure.

Widespread interest is manifest in the outcome, not alone because of the engineering angles involved in drilling the inclined hole and killing the well, but also because the project is being undertaken to prevent the dissipation of natural gas energy and conserve the oil and gas resources of the field. While it marks a new departure in field practice, it also emphasizes the responsibility each operator owes to other operators in the field. It is to be noted that this well upon which so much thought, time and money are now being expended in an effort to kill it, was brought in under complete control as a good producer last year. Subsequent cratering of this well was caused by an adjacent well that blew out and cratered before it was brought under control. The train of havoc that has followed in the wake of the blow-out of one well in this case illustrates the necessity for adopting strict drilling regulations in fields where subsurface conditions similar to those in the Conroe field are encountered.

« « « HIGHLIGHTS IN OILDOM » » »

Continued Drilling in East Texas

The East Texas oil field, although now drilled to an average density of one well to every 10½ acres, continues to be the most active district in the United States. This continued volume of drilling will inevitably result in the establishment of lower allowables per well until the average producing well will be permitted but a negligible output. During the month of October a total of 363 wells were completed, of which 360 produced, while 338 new locations were made. These figures indicate that the ultimate per well density has not been reached. The crowding of wells into the East Texas field will increase the depletion of the gas which is a major factor in maintaining natural flow. Completions during a recent seven-day period included five pumpers scattered at intervals along the east, south and north edges of the field. Heretofore, the completion of wells requiring lifting equipment so early in their life have been rarities in East Texas.

•

Active Prosecution of Oil Code Violators Due Soon

With the appointment of LaVergne F. Guinn, Dallas attorney, as a special assistant Federal Attorney General in charge of Texas oil code cases, and the arrival in Dallas of Cullen A. Phillips, special agent of the Oil Enforcement Division of the Bureau of Investigation, active prosecution of violators of the oil code will likely be started at once.

•

Industry May Be Affected By Russian Recognition

The petroleum industry is vitally interested in the move on the part of the U. S. Government toward recognition of Russia. There are several angles of special significance to the industry involved, one of which has to do with the development of an international oil plan for minimizing unfavorable market conditions.

A primary motive in the recognition of Soviet Russia is to widen the market for American products, and in this connection it appears that manufacturers of oil field supplies and equipment would be in a position to expect large orders from Russia, where production has declined largely because of the lack of modern drilling and producing equipment.

Producers and marketers of crude petroleum and its products are likewise interested because of the possible effect the development of the large Russian reserves might have on the markets of the world.

Report on Interstate Shipment of Crude Oil Issued

For the first time complete current data on the movement of crude oil in interstate commerce are available. The first report on the interstate shipment of crude received by petroleum refineries has been issued by Administrator Ickes. The report is based on information submitted by petroleum refineries in compliance with the administrator's order of September 29, 1933. The report includes only crude oil received by petroleum refineries operating in the United States and does not carry any figures on crude petroleum exportations. Similar reports will be compiled monthly in the future.

•

Production Allocated for December-January

A daily average oil production of 2,130,000 bbl. will be allowed during the months of December and January, it has been announced by the Oil Administration. This compares with a quota of 2,338,500 bbl. for October.

•

Price-Fixing Hurts Skimming Plant Operators

Mid-Continent operators of skimming plants will find it difficult, if not impossible, to make a profit on the fixed crude prices to become effective December 1. Only refiners making a complete line of products will have an opportunity for profit under the schedule. Therefore, the necessity for efficient cracking undoubtedly will be intensified under the crude price control plan. A study of the situation shows that the highest possible percentage of valuable products must be obtained from every barrel of crude run to stills.

For example, with crude produced in East Texas bringing a base of $1.17 per barrel and assuming a 30 per cent recovery of gasoline, the return from gasoline would be 75½ cents for each barrel of crude run to stills. Then assuming a 5 per cent loss, there would be 65 per cent fuel oil that would net the skimming plant operator 47½ cents, making a total income of $1.23 for each barrel. This would leave a margin of only 6 cents to cover gathering, refining and selling costs, factors that would likely run his loss to 18 or 20 cents per barrel. The position of the operator of an efficient cracking plant, on the other hand, will be far different as he obtains a higher percentage of gasoline and more valuable by-products. It appears that cracking will be imperative for the average refiner.

Why be "PENNY WISE" in Materials –only to lose DOLLARS in repairs and leakage later?

THE savings it is possible to make initially, by using a cheaper joint, may look good on paper; but just a few faulty joints may quickly rub such "savings" out. Continual expense *following* installation can be avoided only by using the best, not the cheapest, joint construction at the start.

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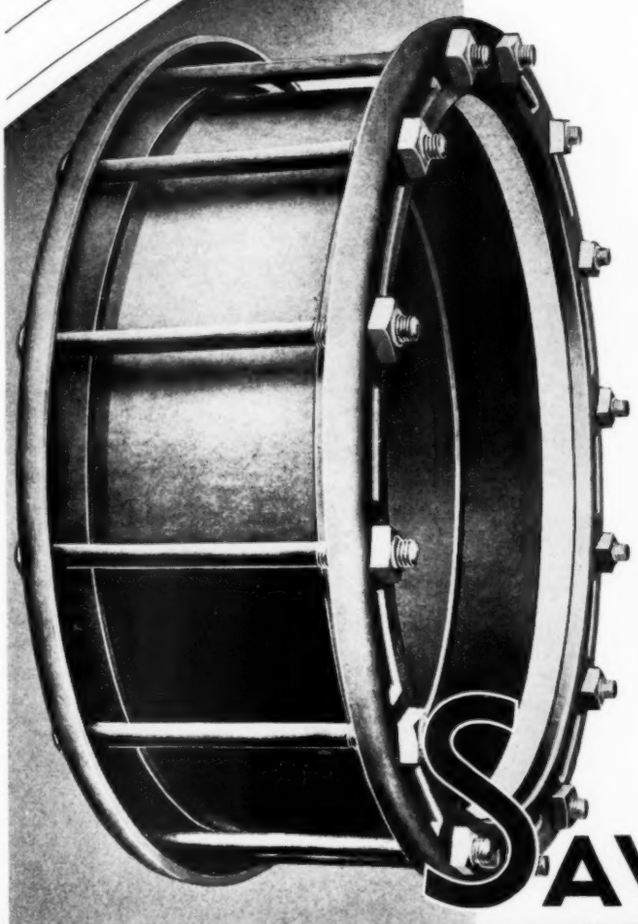

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LATEST ACTIVITIES IN THE OIL FIELDS

RECENT developments in the Palestine area are the basis for an ambitious development and exploration campaign in the south end of the Woodbine belt of East Texas. Tests getting under way assure the industry of an early showdown as to whether production covers a wide area. General opinion is that a series of producing structures is likely to be uncovered.

During the past month the second field in this district was opened. It is situated on what is known as the Buffalo structure in Leon County, about 22 miles southwest of the recent strike at Long Lake in Anderson County. Having tested 48,000,000 cu. ft. of wet gas from the upper section of the Woodbine horizon, the unitized Buffalo project is proceeding slowly deeper in search for oil.

Tide Water Oil Company and Texas Seaboard Oil Company's discovery well of the Long Lake area was pinched from five bbl. of fluid per hour to a point that will not exceed the fuel requirements of a near-by drilling test. The well was making only about five per cent salt water when placed on the smaller choke.

●

The findings of two tests in the Lucien-Perry pool of Noble County, Okla., indicate the existence of a fault along the west side of the field. The location of the fault has not been definitely determined but present indications are that its trend will be a few degrees west of north.

●

A new high production for the Crescent oil field, Logan County, Okla., has been registered by the Continental Oil Company's McConnel No. 1, which made 5708 bbl. initial flow in 24 hours. The field was also extended three-quarters of a mile northwest during the month.

The Texas Company's Iles Investment Company No. 1, one foot in the Sundance sand at 3447 ft., started flowing at the rate of 2000 bbl. daily. The well is an eastern extension of the Iles Dome field, northern Colorado, and found the top of the sand 90 ft. higher than wells to the west.

●

The Serpentine sand play in Bastrop County, Texas, gained considerable impetus as the result of a well that flowed 1000 bbl. in 12 hours. The well is in the North Dale area and is the most prolific completion ever recorded in that immediate sector.

●

Considerable new acreage has been placed in the proven class in the Government Wells, Duval County, South Texas, field, as a result of a good producer one-half mile northwest of production.

The Government Wells group definitely added another pool when a 20-bbl. per hr. well was completed four miles north of production. The well is of great importance since it establishes production in the Cole sand. Also it is several miles south of a gasser in the Government Wells sand and there is a possibility of production connecting both wells with the North Government Wells field proper.

●

The producing limits of the Tomball field in Harris County, Gulf Coastal Texas, were extended 1½ miles in a northwesterly direction into Montgomery County. The extension well is flowing eight bbl. an hour through a 5/32-in. choke. Lack of storage has prevented the taking of a production test.

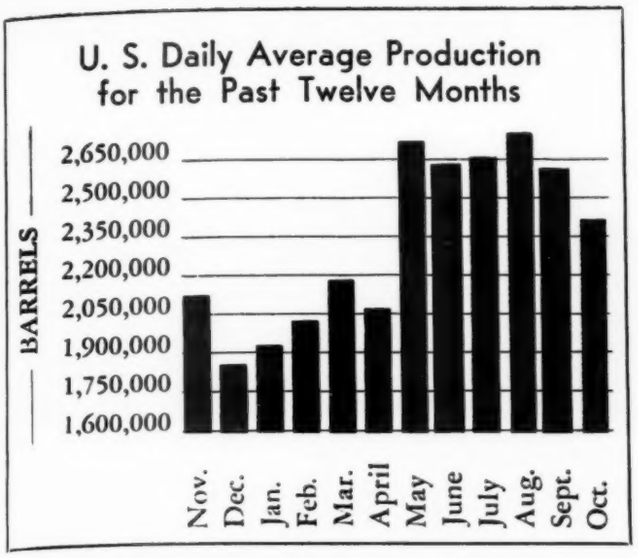
AVERAGE CRUDE OIL PRICES

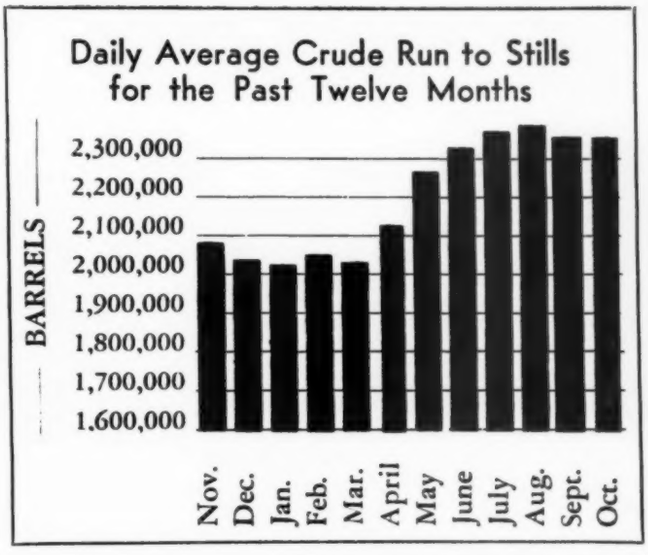
California		Arkansas	$ .70
Playa Del Rey	$ .90	Louisiana	
Coalinga	.81	North Louisiana	.95
Long Beach	1.00	Gulf Coast	1.04
Signal Hill	1.12	Illinois	1.22
Montana	1.10	Kentucky	1.17
Wyoming	1.00	Indiana	1.15
Colorado	1.00	Ohio	
New Mexico	.75	Lima	1.30
Texas		Wooster	1.15
North Central	.95	Michigan	1.02
Panhandle	.83	Pennsylvania	
West Texas	.70	Bradford	2.45
Gulf Coast	1.04	Southwest	2.12
Darst Creek	.87	Corning	1.20
East Texas	1.00	West Virginia	2.07
Kansas	1.00	Canada	2.10
Oklahoma	1.00		

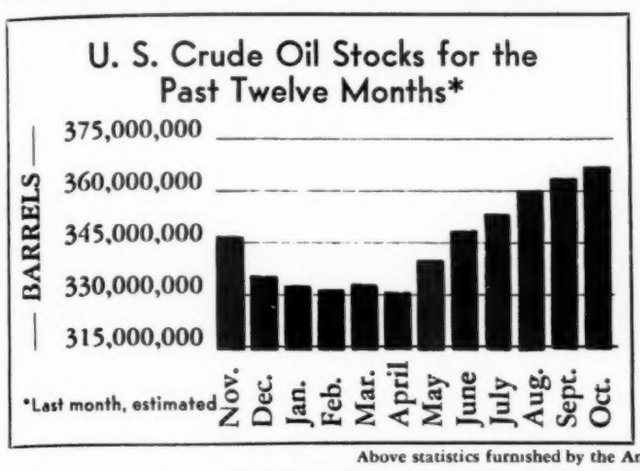
DAILY AVERAGE CRUDE OIL PRODUCTION
(Figures in Barrels)

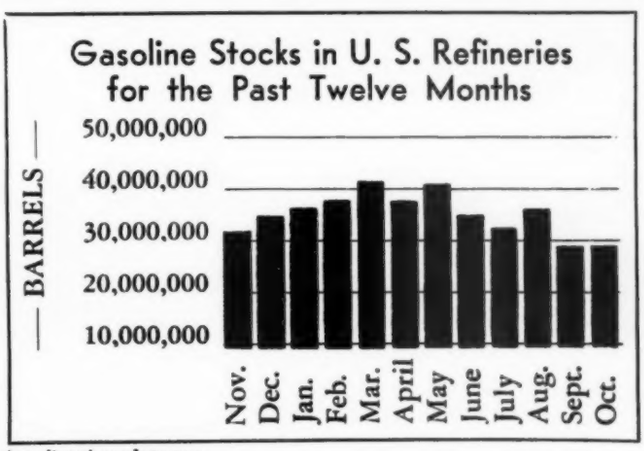
	Furnished by A.P.I.			
	Federal Allowable Effective Oct. 1	W'k Ended Oct. 28, 1933	W'k Ended Sept. 30, 1933	W'k Ended Oct. 29, 1932
Oklahoma	495,000	471,050	527,650	395,400
Kansas	116,000	111,750	121,650	95,900
Panhandle Texas		45,200	45,600	44,100
North Texas		53,300	53,100	47,350
West Central Texas		23,400	21,800	24,850
West Texas		122,000	127,700	148,900
East Central Texas		44,400	46,300	49,350
East Texas		464,600	476,600	341,800
Conroe		73,650	73,400	16,500
Southwest Texas		47,850	46,750	52,900
Coastal Texas (Not incl. Conroe)		112,250	112,100	109,800
TOTAL TEXAS	965,000	986,650	1,003,350	835,550
North Louisiana		26,250	25,800	29,300
Coastal Louisiana		48,200	47,850	34,750
TOTAL LOUISIANA	70,000	74,450	73,650	64,050
Arkansas	33,000	32,850	32,450	34,000
Eastern (Not incl. Michigan)	94,200	96,450	99,600	98,900
Michigan	30,000	29,800	30,000	32,700
Wyoming	30,050	29,850	30,950	34,000
Montana	6,450	6,700	6,600	6,400
Colorado	2,400	2,450	2,350	2,700
New Mexico	41,400	41,950	42,000	31,900
California	455,000	474,200	476,600	475,100
TOTAL	2,338,500	2,358,150	2,446,850	2,096,600

[1]Production figures furnished by the American Petroleum Institute.









Above statistics furnished by the American Petroleum Institute

Summarized Operations in Active Fields for October, 1933

Fields	Completions	Producers	Locations	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
Texas									
East Texas	363	360	338	75	157	3600	2	40	Rotary
Duval County	40	29	30	8	31	2300	2	22	Rotary
Conroe	47	43	68	19	46	5200	2	38	Rotary
Refugio County	23	21	32	7	37	3000–7400	3 or 4	40	Rotary
Oklahoma									
Oklahoma City	9	8	18	21	37	6500	3	39	Rotary
Kansas									
McPherson County	23	22	22	5	31	2900–4300	2	38	Rot-Cab.
Ellsworth Arch	19	14	18	11	33	3300	4	37	Cable
Harvey County	11	11	11	6	26	3450	2 or 4	37	Rot-Cab.
California									
Kettleman Hills	2	2	1	3	21	8300	3 or 4	40	Rotary
Long Beach	5	5	2	5	20	7000	3	26	Rotary

Field Activities by States for October, 1933

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1932 (In Barrels)
	October	September	October	September	October	September	October	September	October	September	
Arkansas	3	0	0	0	3	3	8	7	28	29	11,907,000
California	46	27	45	27	35	116	41	57	130	134	178,128,000
Colorado	2	3	0	0	....	....	6	5	51	50	1,177,000
Illinois	0	3	0	1	....	....	1	1	12	13	4,661,000
Indiana	25	0	18	0	....	....	1	1	46	29	804,000
Kansas	71	67	57	45	74	60	35	41	108	124	34,300,000
Kentucky	16	18	10	9	....	....	2	2	51	54	6,264,000
Louisiana	63	42	36	19	72	49	54	47	157	137	21,478,000
Michigan	43	32	37	23	47	58	105	98	137	115	6,729,000
Mississippi	8	2	4	2	....	....	11	8	19	15	Gas Prod.
Montana	5	10	4	8	....	....	3	4	38	41	2,449,000
New Mexico	5	6	4	1	....	....	5	7	56	52	12,511,000
New York	4	9	1	9	....	....	1	2	18	19	3,501,000
Ohio	106	70	57	55	....	....	35	40	137	133	4,597,000
Oklahoma	133	85	88	50	171	111	88	81	308	300	151,621,000
Pennsylvania	43	100	36	25	....	....	28	21	137	116	12,403,000
Texas	840	503	674	467	831	881	214	219	823	837	311,069,000
West Virginia	26	19	21	14	....	....	26	25	68	56	4,472,000
Wyoming	9	3	4	3	....	....	8	9	69	67	12,359,000
Total	1448	999	1096	748	1233	1278	631	675	2263	2321	781,845,000

PROGRESS OF MAJOR PIPE LINE WORK

By WARREN L. BAKER

THE Stanolind Pipe Line Company has awarded a contract to Williams Bros., Inc., Tulsa, Oklahoma, for the construction of a 42-mile, 8-in. welded pipe line from the south end of the Lucien-Wentz pool, southwest of Perry, in Noble County, Oklahoma, to tie in with its main trunk line near Drumright. Work is to be rushed and it is expected that the artery will be in operation by December 1. This outlet will be the third from this field.

●

Skelly Oil Company has announced that it is preparing to construct a 54-mile pipe line into western Kansas so that oil from pools in this area may be transported to its Eldorado, Kansas, refinery. The company will extend its gathering lines from Burrton, in Harvey County, through Reno County to the Cunningham field in western Kingman County, where the company has extensive holdings. From Burrton west 30 miles the line will be 8 in., and for the remaining 24 miles the line will be laid with 6-in. pipe. The new line will give Skelly 80 miles of 8-in. pipe in Kansas, Contract for the construction of the 48-mile extension has not been let, although right-of-way has been obtained and 25 miles of pipe already purchased and unloaded at Burrton. This pipe line program, it is thought, will cost $300,000.

●

An official of the Houston Natural Gas Company, Houston, Texas, has announced that his company will build in the near future a natural gas pipe line from the Conroe and Tomball fields to serve customers in Houston. The pipe line will be built by the Balcones Company, Inc., of Houston. Both fields are approximately 30 miles from Houston.

●

The Central Pipe Line Company, Springfield, Ill., has received a general charter to engage in natural gas and oil operations. The company, a subsidiary of the Panhandle Illinois Pipe Line Company, will construct two natural gas lines in central Illinois. The company has let a contract to Williams Bros., Inc., for the construction of these two lines, one a 6-in. line from Bartonville to Canton, which will serve in addition to the above two cities Havana, Bushnell, Cuba, Macomb and Lewiston. The other line will be a 4-in. one from Danville to Hoopeston and will also serve Rossville.

Work is progressing rapidly on the 36-mile 18-in. gas line being laid from the Shaffer gas field in eastern Rush County, Kansas, to tie in with the Northern Natural Gas Company's 26-in. line at a point near Bushton in northwestern Rice County. Truman-Smith, Eldorado, Kansas, contractors, have the contract on the main line and White Construction Company, Wichita, is laying an 8-in. gathering line and the 4-in. laterals.

●

A new 6-in. line of the Sinclair-Prairie Pipe Line Company is being laid from the old Florence field, Marion County, Kansas, to Augusta, Butler County, where it connects with the company's main line. This will replace an old line laid 12 years ago. Truman-Smith are the contractors.

●

Right-of-way for 28 miles of natural gas pipe lines in Ottumwa and Wapello counties, Iowa, has been obtained by the Natural Gas Pipe Line Company of America, Chicago, Ill. The lateral would include Mount Pleasant, Fairfield and intermediate communities.

●

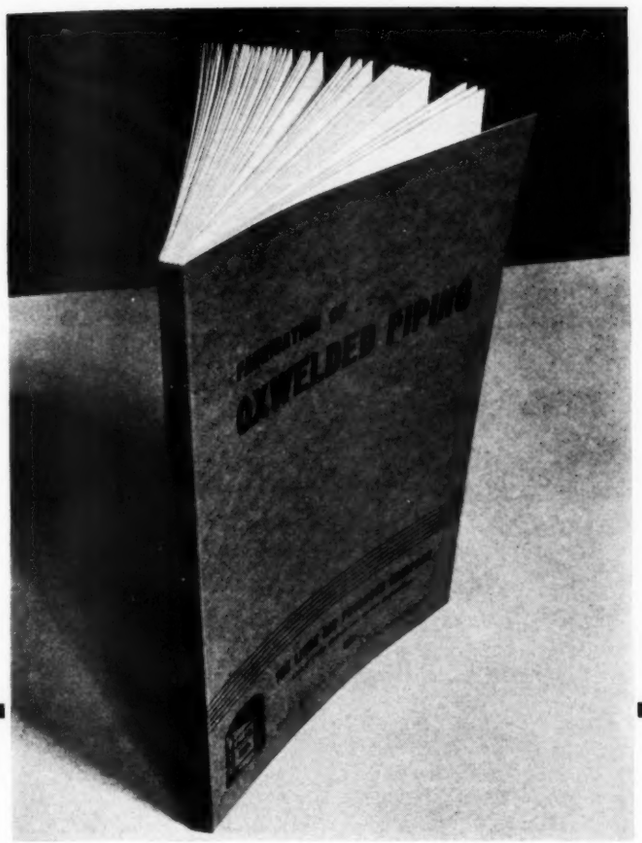
Work at the Phoenix, Arizona, end of the Western Gas Company's Douglas-Tucson-Phoenix, Arizona, extension was commenced late in October by Becktel-Kaiser Company, Ltd., and the Henry J. Kaiser Company, joint contractors on the line. The first construction work at this point is the laying of a section across the Salt River.

●

An outlet for the Jeffries-Lambeth gas field in eastern Starr County, southwestern Texas, will be provided by the Rio Grande Public Service Company. A 12-mile line will be laid from the Los Olmos pool to gather gas in the new pool.

●

Stanolind Pipe Line Company plans to start work in December on the construction of a 6-in. line that will connect the various oil pools of Russell County with its present system terminating in the Stalkenburg pool of Ellsworth County, Kansas. The new line's western terminus will be Paradise, Kansas, where the Stanolind Crude Oil Purchasing Company's gathering system in Russell County will be tied in with the new outlet. This should increase the amount of exploration work in western Kansas, which has been lacking in pipe line facilities.



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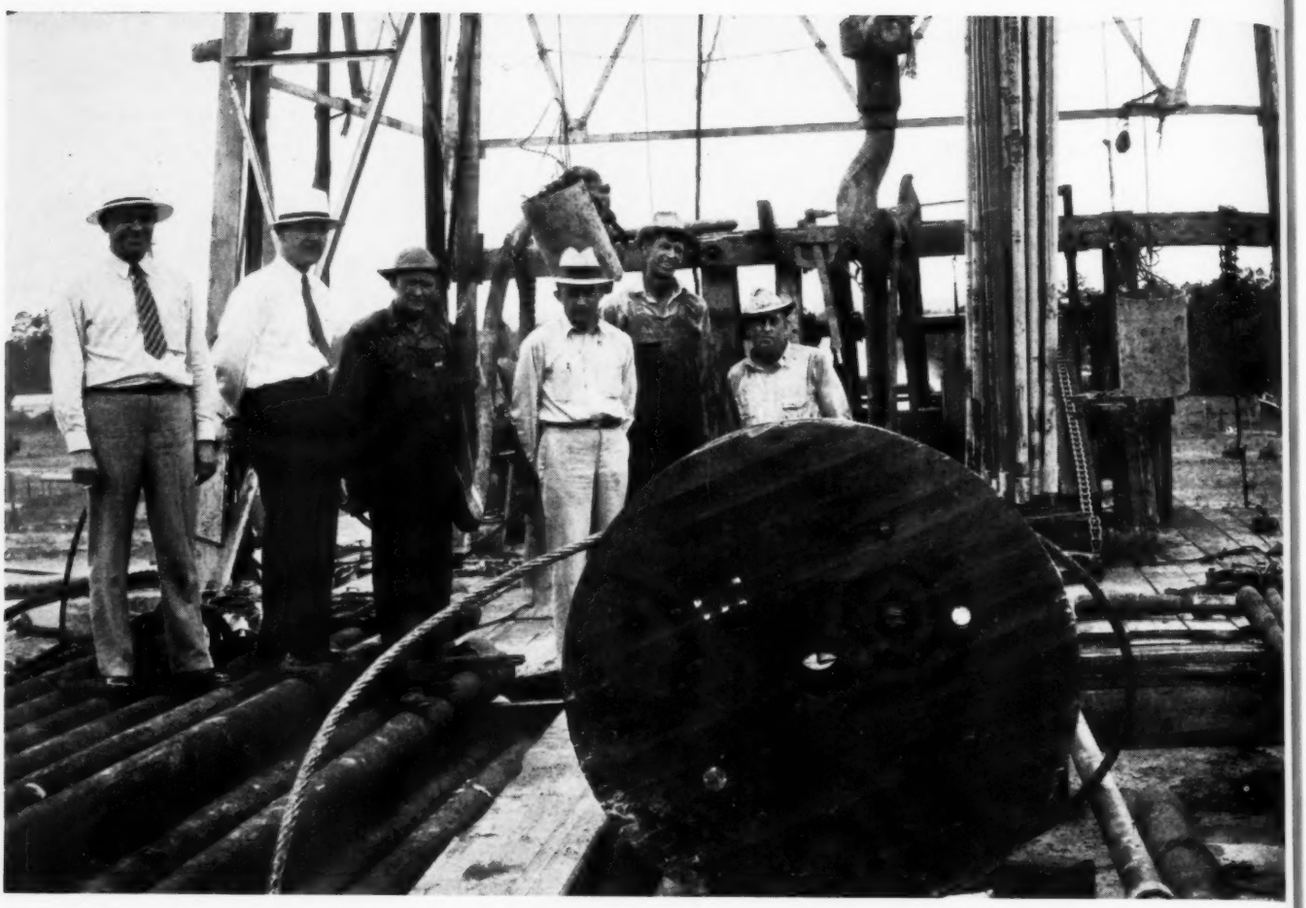

Wire Rope QUALITY Insures Low Cost per-foot-of-hole

Campbell & Parker Drilling Co., drilling for Turman Oil Company. Well, Robert Dark No. 7, near Joinerville, Texas.

The men, left to right—J. R. Custer, Jarecki Mfg. Company, Gladewater, Texas; H. R. Cutlip, Union Wire Rope Corp.; Jack Jackson, Driller; A. D. (Dick) Barnett, Tool Pusher, Campbell & Parker Drilling Co.; Paul McElrath, Crew; Henry Jones, Crew.

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THE MONTH'S ACTIVITIES IN REFINING

By F. R. STALEY

Per Cent Refining Capacity Operated

Eastern Division, 73.6 Per Cent **Central Division, 72.8 Per Cent** **Western Division, 50.1 Per Cent**

CRUDE oil runs to refinery stills continue to increase. During the week ending October 28 they reached a daily average of 2,360,000 bbl., according to the American Petroleum Institute, as compared with a daily average of 2,312,000 bbl. charged to stills during the week ending September 30. This excessive amount of crude run to stills, in face of a declining consumer demand that cannot be expected to increase before next spring, has resulted already in the addition of over 2,000,000 bbl. to motor fuel stocks. Since these additions to storage cannot be readily absorbed at this time, a condition has been created that may defeat and, at least, seriously hinder efforts of government administrators to maintain a fair price for gasoline. Thus, while producers have been lowering crude oil production, the overproduction of gasoline has been increasing. Consequently, the improved outlook for the industry created by lower crude production has been revoked by the practice of refiners of charging more oil to stills than is needed, evidently in anticipation of the price fixing schedule to be applied December 1. However, the government is likely to demand that crude runs be brought into line before official fixing is established.

●

One of the largest oil contracts ever negotiated in the Far East has been signed by Soviet Russia with the Japanese-owned South Manchuria railway. The Soviet Naphtha Oil Syndicate has agreed to supply the railway with 500,000 gal. of gasoline during the first year of the agreement, 1,000,000 gal. in the second year and as high as 5,000,000 gal. annually for five years. The price is understood to have been eight cents per gal., which is one of the lowest prices quoted in recent years. Heretofore, American and British-Dutch oil companies have supplied large quantities to the South Manchuria railway.

Smith Brothers Refining Company, recently organized, has under construction a 30,000-gal. natural gasoline plant at McLean, Texas. The plant, when completed, will include three absorption units and a distillation unit. The general contract for the design and construction of this plant has been awarded to the Tulsa Boiler & Machinery Company.

●

The Altitude Petroleum Corporation is completing work on the new absorption plant at its Chanute, Kan., refinery. The absorption equipment is thoroughly modernly designed to make all grades of absorption gasoline, principally from cracked gases available at the refinery. The capacity of the refinery is also being increased. The construction work is in the hands of Petroleum Engineering, Inc., affiliates of Arthur G. McKee and Company.

●

The Garber Refining Company's plant at Garber, Okla., has been purchased at bankruptcy sale by the Omar Refining Company and will probably be in operation by November 18. The plant, which has been shut down for a year, is being revamped by the installation of modern equipment. Although the plant has a capacity of 4500 bbl. of crude oil daily, it is thought that crude run to stills will, at first, not exceed 2500 barrels.

●

Ampco Engineering Company, Dallas, Texas, has completed construction work on a 1200-bbl. topping plant for the Shamrock Oil & Gas Company at Le Flors, Texas.

●

Cargray Corporation of Amarillo, Texas, has completed a 75,000,000-cu. ft. Tulsa Type absorption gasoline plant at Pampa, Texas. Approximately 20,000 gal. of natural gasoline is being manufactured daily in the new plant. The finished product is being taken by the Phillips Petroleum Company.

Crude Runs to Stills, Gasoline and Gas and Fuel Oil Stocks, Week Ending October 28, 1933

A.P.I. Figures

(Figures in Barrels of 42 Gallons Each)

DISTRICT	Per Cent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Per Cent Operated of Total Capacity Reporting	Total Motor Fuel Stocks Thousands of Bbl.	Gas and Fuel Oil Stocks Thousands of Bbl.
East Coast	100.0	481,000	82.6	13,639	9,093
Applachian	92.6	88,000	63.0	2,057	910
Ind., Ill., Ky.	97.3	322,000	75.8	7,310	6,183
Okla., Kans., Mo.	82.1	234,000	61.7	5,848	4,318
Inland Texas	60.2	92,000	55.7	1,379	1,837
Texas Gulf	98.1	506,000	95.9	5,897	6,348
Louisiana Gulf	100.0	128,000	79.0	1,188	2,085
No. La.-Ark.	92.6	55,000	71.9	244	646
Rocky Mountain	78.8	31,000	48.7	857	726
California	96.9	423,000	51.5	14,308	96,467
TOTALS WEEK:					
October 28, 1933	92.4	2,360,000	70.6	52,727	128.613
October 21, 1933	92.4	2,348,000	70.9	52,752	129,898

Summary of Operating Factors Contributing to

By ROBERT R. ROBINSON
Consulting Mechanical Engineer,
Los Angeles

THE close study that has been given to pumping conditions in the past few years has resulted in a large number of investigations directed to individual factors contributing to pumping efficiency. Many of these have been directed to problems of general application—others to specific conditions applicable to but a small number of wells, or to conditions in a particular district. It is the purpose of this article to summarize a few general rules applicable to the majority of pumping installations. Of course, the application of all of them to every possible condition cannot be expected, but they do apply in the majority of cases and the exceptions are easily recognized.

The discussion is likewise limited to operating factors, that is, those conditions that can be changed easily at the rig without requiring major changes in equipment. It is likewise directed to those wells in which fluid production is limited —in other words, where the object of change is to increase the efficiency in lifting a definite quantity of oil.

Elimination of Gas. Proper pump operation cannot be obtained where free gas in quantity is allowed to pass through the pump. Fluid level, pump location, and formation conditions govern the quantity of gas entering the tubing. We must assume that the inlet to the pump is so located that the quantity of entering gas is a minimum. Fluid level is, of course, dependent upon the rate of in-flow, formation pressure, and production. Efficient operation can be obtained if the fluid level is maintained slightly above the highest level of the plunger valve. Inasmuch as high fluid levels restrict the rate of fluid in-flow to the well, to obtain maximum production, the level must be mtaintained at the lowest feasible point. But, under present restricted production conditions, it is often more economical to maintain higher fluid levels at the expense of production.

The next step, after eliminating as much gas as possible prior to fluid entering the tubing, is to prevent the gas that does enter from getting into the pump. Numerous as are the types of anchors in use, few of them are correctly designed for the installations they serve. Where fluid levels are low, the length required for the installation of the usual gas anchor is often allowed to eliminate its consideration. Length is not necessary for efficient gas separation. For wells of low production an efficient gas anchor can be made to take up a depth of less than three feet below the bottom coupling, even where diameters are limited. The inside diameter of the anchor should be as large as possible and the outside diameter can be as large, if not larger, than the bottom pump coupling. The inlet to the pump need not be much larger than the opening through the standing valve. The necessary relationship for efficient separation is that the angular space through which the gas rises gives the maximum free area and that the capacity in the outside space between the lowest inlet hole of the anchor and the inlet to the pump be greater than the capacity of the pump per stroke. Approximately twice the capacity of the pump at the longest stroke is advisable as a minimum.

Minimizing the effect of gas that does enter the pump is accomplished by the provision of the usual bottom plunger valve, minimum bottom spacing, and use of the longest feasible stroke.

Other features tending toward the elimination of pumping troubles due to gas will be discussed in conjunction with stroke and speed relationships.

Stroke, Speed and Pump Size. These factors must, of course, all be considered together in order that production shall reach the desired figure. Inasmuch as the size of the plunger is the basic factor in determination of rod loadings, its effect on production difficulties will be considered first.

The smaller the size of the plunger, the less the fluid

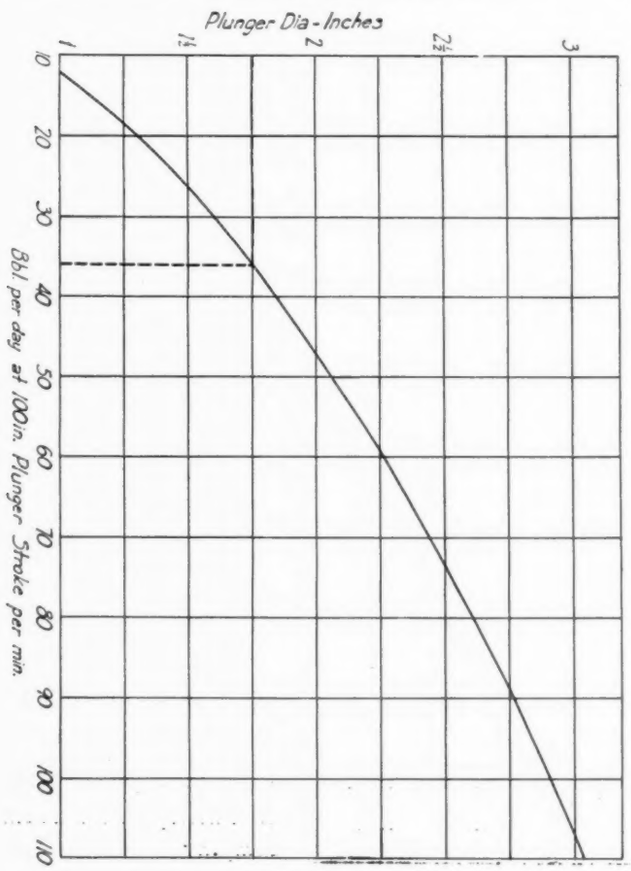


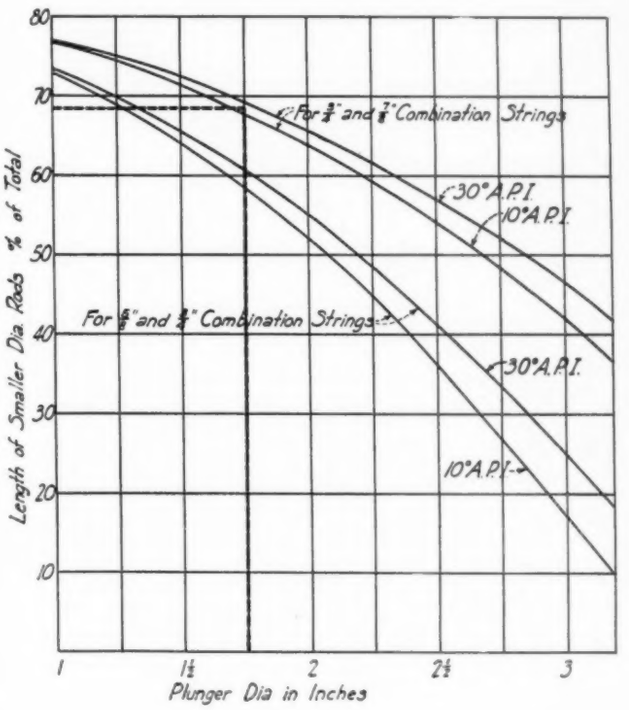
FIG. 1

Curve for estimating pump capacities. Obtaining capacity for 100 in. plunger stroke per minute from bottom scale for plunger size selected at left. Multiply by the product of the plunger stroke in inches and the strokes per minute divided by 100, or (L X N)/100

to Maximum Pumping Efficiency

FIG. 2

Curve for determining proportions of combination sucker rod strings for equal unit stresses. Run vertically upward from plunger size to combination desired and read at the left the percentage of the string that will be composed of the smaller sized rods



load. Fluid load is the basic variable loading on the rods. Furthermore, the flow of the fluid is started upward and stopped at each stroke, except where large quantities of gas are present. Therefore, the weight of the fluid determines to a large extent the dynamic loadings on the rods; hence, smaller sized pumps reduce not only the maximum loads on the rods, but also reduce the load range, both of which are extremely important in obtaining long service from a string of sucker rods.

Rod failures are primarily from fatigue. Seldom do parted sucker rods exhibit any of the characteristics of pure tensile failure. Sometimes they may exhibit signs of failure from bending or buckling, but even in these cases fatigue is the basis of the failure.

A sucker rod having an ultimate tensile strength of 90,000 lb. per sq. in. will have an endurance limit of probably about 40,000 lb. per sq. in. when operated perfectly dry. In a well, however, the factor of corrosion always enters to some extent, and effects a surprising reduction in strength under repeated stresses. Even the ordinary city water supply will cause a reduction in the endurance limit to between one-quarter and one-third of the ultimate tensile strength, according to actual test. If we consider that the usual well conditions cause no greater reduction in fatigue strength than that of drinkable water, then a ¾-in. sucker rod has a safe working limit of between 9950 and 13,250 lb., and a ⅞-in. rod between 13,500 and 18,000 lb., depending upon whether we accept the one-quarter or the one-third proportion.

Records from a large number of wells have shown that the lower figure is more nearly correct for sucker-rod steels in general use and for normal well conditions. ¾-in. rods operating below 10,000 lb. have been found to give extremely long service, even in wells making high percentages of water, while the length of service between breaks decreases rapidly until at 14,000 lb. and above breaks are very frequent, and the life of the string is short. The effect of increasing the rate of corrosion by service in more corrosive fluids seems to be to decrease the period of time before failure rather than to lower the fatigue strength. On the other hand, in extremely clean oil, long life at 14,000-lb. loads and even above has been obtained.

While records are by no means complete, it has been found possible almost to double the life of a string of rods by reducing the load from 14,500 lb. to 12,500 lb., a reduction in maximum load of but 15 per cent. Consequently any reduction in fluid load that can be obtained by the use of a smaller pump will reduce rod trouble to a large extent; therefore, where feasible, the smallest possible pump diameter should be used. Smaller fluid loads also decrease the loss due to the stretch in the rods, consequently with a small diameter pump a greater proportion of the stroke is effective.

Fig. 1 is a curve that the writer has found very convenient for estimating pump capacities, giving the daily capacity in barrels for each plunger size at 100 in. effective pumping stroke per minute.

Where the oil is heavy and viscous it may, of course, be necessary, regardless of other considerations, to use large diameter pumps in order that fluid passages be large enough to permit free dropping of the plunger.

Speed. Since dynamic loads, due to the alternate reversals of rod motion and to the dropping and picking up of the fluid load, increase rapidly with speed increases, it is advisable to keep speeds as low as possible. Below ten 34-in. strokes per minute, there is little advantage to be gained in load reduction from slower speeds alone, so long as the pump is operating at approximately full volumetric efficiency. Up to 15 strokes per minute, the gain is small, but becomes increasingly noticeable, and between 25 and 30 strokes per minute, dynamic loads often add as much as 50 per cent to static load figures.

But there are other considerations than maximum loads and load ranges in selecting speeds. Plunger and barrel wear is dependent upon the number of times their surfaces are rubbed together, in other words, upon the total number of strokes. A million 34-in. strokes will wear out the pump to the same extent as a million 72-in. strokes, yet will pump

less than half the amount of oil.

Slower speeds have also proven definitely advantageous from the standpoint of gas and sand. The well fluid is agitated less by slower speeds, even though the strokes be longer, thus releasing less gas and pulling less sand into the pump. It must also be remembered that, at high speeds and in deep wells particularly, the tubing is moving up and down at each stroke. Instances have been found where this movement has been proven to be as great as 14 and 15 inches. The effect of this motion on agitating the well fluid, and its consequent sand washing, is obvious. Lower speeds and smaller pump sizes decrease movement of tubing.

Stroke. With minimum size pump and slow speed, a long stroke becomes necessary to obtain the desired production. What are the advantages or disadvantages of long strokes? The fluid level should always be high enough to fill the barrel to the highest position of the working valve. This means that a slightly higher fluid level must be maintained when using a long stroke than when using a shorter one.

Above the ground, heavier counterbalances will be required for pitman and crank types of balances. Beam balances are not desirable when such long strokes are used except at very slow speeds. Heavier pumping gears are also necessary. These disadvantages are not serious, and are relative only.

An the other hand, a much smaller proportion of the stroke is lost in rod stretch in pumping with a long stroke. Similarly, owing to the much smaller proportion between clearance and displacement, free gas is not so likely to lock the pump. Therefore, in order to keep pump size and speed as low as possible, the stroke should be as long as possible.

Rods. To keep rod loads as low as possible, the rod string itself should be as light as possible. The only way of lightening a string of rods so as to reduce the unit stress in them, is to taper the string. Seldom are more than two sizes of rod justified in a single string, yet in many cases it may be found advisable to use three sizes. In Fig. 2 is shown the percentage of the small diameter string plotted against the plunger diameter for combinations of ⅝-in. and ¾-in. and ¾-in. and ⅞-in. sucker rods, respectively, to give equal unit stresses in the two sizes of rods. For pumping water and for 30 gravity oil, the values for intermediate gravity oil may be estimated with sufficient accuracy for practical purposes. The formulae from which these curves are drawn are based upon those given in a paper by B. H. Robinson before the A.P.I. in November, 1931.

In Fig. 3 is shown the maximum depths for various sizes of plunger diameters when utilizing combination rod strings, as determined from Fig. 2, so that the unit stresses in the rods do not exceed 25,000 lb. per sq. inch.

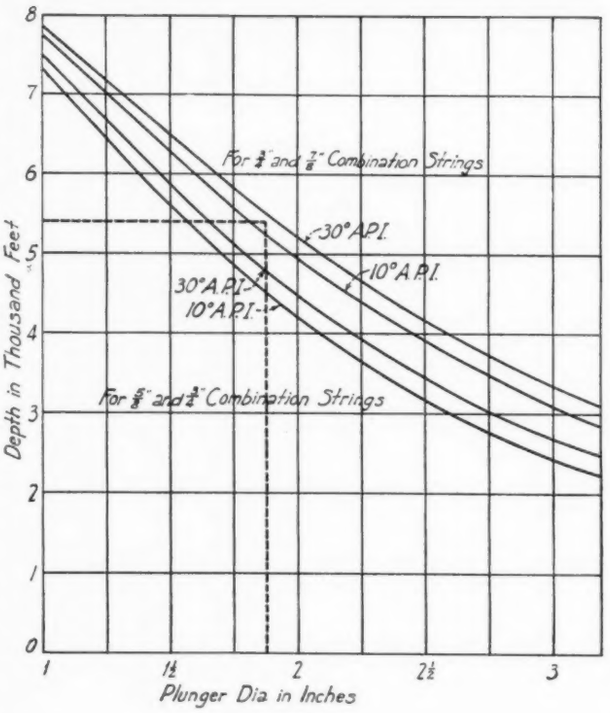


FIG. 3

Curve for selection of plunger sizes for combination rod strings to avoid over-stressing rods. Read to the right from depth of pump to intersection with curve. Vertically below will be found the largest plunger that can be used to maintain unit stresses under 25,000 lb. per sq. inch. Select next smaller standard plunger. Curve is based on static loads. For speeds greater than 15 s.p.m. reduce plunger size to allow for dynamic loads

While occasionally good service can be obtained from rods under stresses greater than this figure, where possible it is suggested that if stress can be kept below it, longer rod life and more satisfactory service can be obtained.

The use of such combination strings will, in the usual case, lighten the rods sufficiently so that long strokes may be obtained without overloading the pumping gear or counterbalancing equipment available. This is particularly true when the fluid load can be correspondingly reduced by the use of a smaller diameter plunger.

As an example of the use of the curves, supposing that it is desired to pump approximately 300 bbl. of 20 gravity oil per day from a depth of 5400 feet:

From Fig. 3, following the dotted line we find that at 5400 ft. with a combination string of ¾-in. and ⅞-in. rods the maximum plunger that can be used will be 1⅞-in. diameter, the nearest standard size below this being 1¾-inch. We will assume this to be satisfactory. Reference to Fig. 1 gives us the capacity of the 1¾-in. plunger of 36 bbl. per day per 100 in. plunger stroke per minute. Dividing 300 by 36 we find that the length of plunger stroke multiplied by the number of strokes per minute must equal 830, which we will call the displacement factor. Reference to Fig. 2 shows with a 1¾-in. plunger the ¾-in. rods will be 68½ per cent of the total length, 5400 ft., giving 3700 ft. of ¾-in. rods and 1700 ft. of ⅞-in. rods as suggested string.

Fluid load computed in the usual manner is found to be 4280 lb. and the rod stretch caused by this fluid load on ¾-in. rods will be 15 inches, on the ⅞-in. rods will be 5 in., or a total of 20 inches. Taking a 64-in. stroke as the maximum allowed by the equipment available, the net stroke then will be 44 inches. Dividing the displacement factor 830, by 44, we find the number of strokes per minute required to be 19. Adding 15 per cent to the displacement for safety, we find 22 strokes per minute as the required speed.

All this computation has been based, of course, upon static load conditions. At 22 strokes per minute there will be a dynamic load factor of an additional 25 per cent to be added to the stresses in the rod. The total static load figured in the usual manner amounts to 14,400 pounds. Adding this 25 per cent to this static load we have a dynamic load on the ⅞-in. rods at the top of 18,000 lb., figuring 30,000 lb. per sq. in., or somewhat above our suggested maximum. However, under the conditions, this is about the best that can be obtained.

Power. The type of prime mover is usually determined by economic considerations. Operating efficiencies are often sacrificed for other matters, such as available engines and motors, pump gears in stock, standard sizes, etc. The discussion of prime movers and gears is beyond the scope of this article.

Gas Company Uses Butane As Standby

First all-welded Hortonsphere used for gas storage

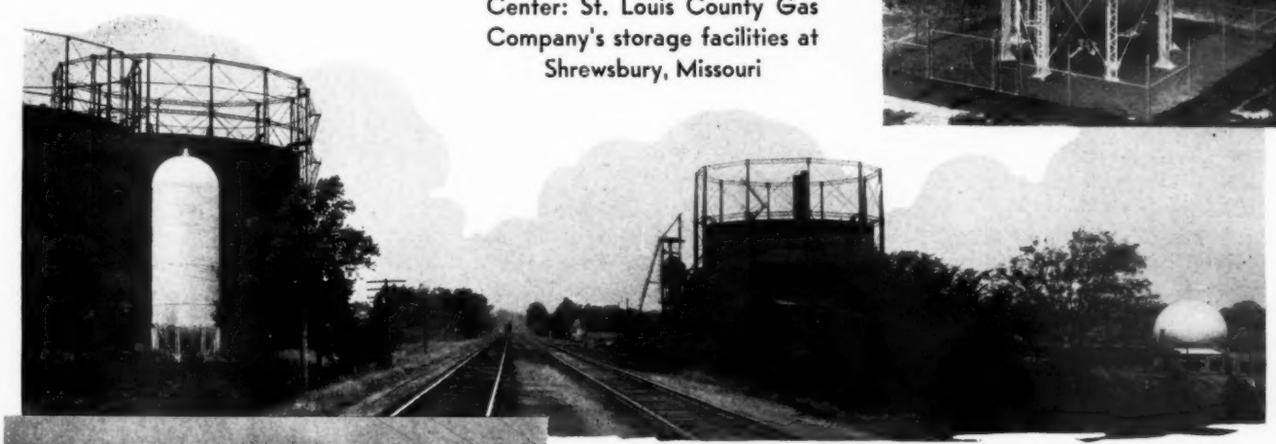
Heating valve is controlled by photo-electric cell

THE St. Louis County Gas Company, at its Shrewsbury, Mo., plant, has pioneered in both the design and construction of gas storage and mixing facilities. For instance, the diffusion holder is the first all-welded Hortonsphere of butt-joint construction to be used for the storage of gas; the application of the mixing and regulating equipment is also largely original; and the vaporizer has a greater capacity than any previous installation. Extensive experimental work was necessary to determine the best method of handling gas in large volume under the existing pressure conditions.

The St. Louis County Gas Company distributes mixed manufactured and natural gas with a heating value of 800 B.t.u. to 20 cities, towns and villages, as well as some unincorporated territory in St. Louis County, Mo. The manufactured gas is made at the company's plant at Shrewsbury, and the natural gas is obtained from Louisiana by pipe line.

Right: Liquid butane storage tank

Center: St. Louis County Gas Company's storage facilities at Shrewsbury, Missouri



Left: All-welded Hortonsphere gas storage container

Prior to contracting for the use of natural gas the gas supply consisted of 570-B.t.u. carburetted water-gas, approximately 93 per cent of which when sent out was compressed to pressures between 12 and 40 lb. per sq. in. gauge. All six compressors used in this service are of the single-stage, twin-cylinder, reciprocating type and are powered for a maximum gas pressure of 45 lb. per sq. in. gauge.

When natural gas at a pressure of 60 lb. or more per sq. in. became available, it was decided to increase the heating value of the gas delivered to the distribution mains to 800 B.t.u. per cu. ft.; to send it all out at high pressure, controlling both the pressure and the rate of delivery by the operation of the manufactured gas compressors; and to store the natural and manufactured gases in separate holders and mix them at high pressure immediately before sending the mixture into the distribution mains. Of the 4½ million cu. ft. of holder capacity at the plant three million was converted to natural gas storage,

the remaining 1½ million being used as manufactured gas storage.

A great deal of thought was given to the matter of providing a supply of gas for the possible emergency that would arise in case of a natural gas outage of long enough duration for the supply of stored natural gas to become exhausted. After experimenting with burners and consulting with others who had made experiments along similar lines, it was decided that the use of butane in connection with the existing water-gas equipment would provide a suitable emergency substitute gas. Consequently, a butane plant was installed as a standby, to guard against interruption in the natural gas supply.

This plant consists of a 150,000-gal. vertical tank for the storage of liquid butane and a vaporizer with a capacity of 120 gal. of liquid per minute. The butane storage tank, which is 22 ft. in diameter and 70 ft. 9 in. high, holds a three days' supply. This reserve capacity is sufficient, as the supply can be replenished from Oklahoma refineries in three days, or from a near-by pipe line terminal in 24 hours. The liquid butane is conducted to a Griscom-Russell vaporizer adjacent to the mixer house where the latent heat of vaporization is supplied by boiler steam. The vapor is then conducted to the mixer through a 6-in. line in which has been installed a butterfly valve, which is mechanically linked to those in the manufactured and natural gas lines and is controlled by a regulator. In the vapor line between the vaporizer and the butterfly is a 4-in. lever valve that is also controlled by a regulator, which serves to control the flow of butane vapor. In the stand-by position the pressure is on the butane and the steam on the vaporizer with the vapor line closed ahead of the mixer by means of a plug valve.

The procedure for handling the load during a natural gas outage is not difficult. The mixer is operated as usual, as will be explained later in this article, on natural gas pumped from a low-pressure storage holder. The manufactured gas is automatically shut off until it is carburetted to approximately 600 B.t.u., the metering butterfly differentials being adjusted as required. When 600-B.t.u. manufactured gas is available, the natural gas is shut off and the butane vapor turned on. The gas then being sent out is the butane-enriched carburetted water-gas with a heating value of 900 to 925 B.t.u., which was found to be a satisfactory substitute for the normal 800-B.t.u. mixed gas.

Butane is moved into and out of storage by the pressure method. When unloading tank cars, manufactured gas is pumped into the cars, forcing the liquid into the tank. The pressure is controlled manually during this operation, being adjusted to equal the head on the line. Except when cars are being unloaded, a compressor maintains a pressure of 60 lb. per sq. in. on the line delivering liquid butane to the vaporizer.

The manufactured gas and natural or butane gas are mixed by means of automatic equipment. A 12-in. line from the discharge of the manufactured gas compressors has been run into the mixer room and about three in. above it, with the lines in the same vertical plane, was constructed a 12-in. natural gas line. In each of these lines is installed a metering butterfly valve, beyond which the two lines are connected to the top and the side of a standard pipe tee with a 16-in. bottom outlet that connects to an underground surge tank. The two metering butterflies are mechanically linked, so that their angularity relationship remains fixed, and the position of both is controlled by one regulator. This regulator is set to maintain a constant differential across a butterfly valve in the manufactured gas line, so that the area of the butterfly opening varies with the flow. Since the regulator moves both butterfles proportionately at all times; and since the downstream pressures are the same, if a constant differential is maintained across the butterfly in the natural gas line then the volumetric relationship between the two constituent gases will remain constant for any rate of throughput or for any pressure on the downstream side. Another regulator, by sequential operation of two turbine-type valves in parallel, performs this function, reducing the natural gas pressure on the upstream side of the natural gas butterfly to a value equal to the downstream pressure plus the differential.

The two regulators, with the valves they operate, are to all intents and purposes a complete volumetric mixing plant.

As this equipment is now in operation the manufactured gas has a heating value of around 280 B.t.u. per cu. ft., and the natural gas a heating value of about 970 B.t.u. per cu. foot. To produce the 800 B.t.u. mixture requires about 75 per cent natural gas and 25 per cent manufactured gas. The differential settings across the butterflies are approximately 1.1 in. and 3.1 in. water, respectively, for the manufactured gas and the natural gas. The range of throughput capacity is approximately eight to one. When the throughput capacity will require to be increased it will be necessary to increase only the differential settings proportionately by changing the regulator loadings.

Small changes in the heating value of either constituent gas are taken care of automatically by means of a Thomas colorimeter which samples the mixed gas at the mixer outlet, and records the results. This instrument is provided with contactors that operate an electric motor-driven actuator that varies the loading on the second mentioned regulator as required for minor corrections. This instrument also operates a signal when the actuator has reached its limit, as well as standard lamp banks at three locations in the plant for indicating the heating value of the mixed gas.

Although it was felt that with this automatic regulating and controlling equipment there was little danger from any shortage of gases, there was still a feeling of uneasiness when speculating upon the effects of the possible failure of one of the regulating units. To allay this uneasy feeling, the company installed a 50,000-cu. ft. high-pressure diffusion holder between the mixer and the distribution system. This holder is a 45-ft. diameter, all-welded, Hortonsphere built by Chicago Bridge and Iron Works; its only function is to introduce a time lag between the passing of the mixed gas from the mixer and the entrance of the mixed gas into the distribution mains. The inlet pipe of this holder extends through the bottom and almost to the top, and is designed to promote recirculation of the gas by means of a venturi-type mixing throat located about two-thirds of its height above the bottom. The outlet pipe connects the bottom of the holder to the distribution main.

Even with the holder in place, considering the time lag in a Thomas calorimeter, there was still a possibility that a regulator failure could allow the sending out of low B.t.u. gas for considerable time before it would become known to the operator. Consequently, it was decided to install some apparatus that would signal low B.t.u. on the mixed gas, and do it instantaneously. The unit finally selected was one made up of a combination of the Caloroptic burner of the Connelly Iron Sponge and Governor Company, a light condensing lens, and a photo-electric cell and relay unit. The gas sample is taken at the mixer outlet and burned in about five seconds thereafter in the burner. With correct heating value the flame is luminous, and when such luminosity is projected through the lens that directs it upon the photo-electric cell, the cell causes the relay circuit to remain open. A decrease in the luminosity of the flame, such as would ensue with a lowering of the heating value of the gas, causes the energizing of the relay circuit. The energizing of this circuit sets a Klaxon horn to sounding and illuminates an incandescent lamp at the operator's station. It is estimated that even under heavy load conditions, the operator would have at least ten minutes to find and correct trouble between the sounding of the horn and the sending out of gas low enough in heating value to cause trouble.

Hints on anticipating trouble, where it is likely to occur, and how to prevent it

Servicing Electric Pumping Rigs

By W. C. LANE
Electrical Engineer

WORKMEN employed in an electrified industrial plant such as a machine shop are much like the average automobile driver in that they are only "starters and stoppers" of the motors used to drive the machines that they operate. There is no occasion for them to be required to understand the care and operation of the motors themselves as the equipment is located in a small area and it is possible to have it inspected frequently by skilled men at a nominal cost per motor. In case it is necessary to make repairs or to replace any of them the management need not give any thought to such things as flooded highways, impassable roads, remote locations or of the availability of competent labor.

The conditions are usually quite different in an oil field. Operations are widely scattered, passable roads during certain seasons of the year do not exist and labor conditions are such that the cost per well of the time of a regular inspector is frequently out of proportion to the service rendered. Major oil operators who use electricity extensively for pumping have enough work of this nature to keep an inspector busy and are justified in maintaining a regular man but the small operator cannot afford to do so. To such it can be said that a little effort exerted in training the regular pumpers in the mechanical operation of electrical devices and in a few elementary electrical principles will do much toward lessening the need for a service man.

It will be found that a large per cent of the so-called electrical troubles encountered can be traced to mechanical causes. Among these may be mentioned such things as low bearings due to improper lubrication or excessive belt tension, the flooding of the stator winding caused by putting excessive oil in the bearings, improper counterbalancing of wells and over-heating of motors due to limiting the amount of the air supplied to them. It is very evident that the secret lies in teaching pumpers to anticipate trouble; to know where it is likely to occur and how to prevent it.

The writer has often wondered why manufacturers and others interested in furthering the use of electrical equipment have not accomplished more toward removing some of the mystery existing in the mind of the average man toward electricity. Unfortunately, the idea has been instilled in the layman's mind that all electrical machinery is complicated, dangerous to handle, and that it takes a specialist to perform such simple operations as changing a set of brushes. If all manufacturers and venders of electrical machinery would only realize that it is important commercially to give definite information on the behavior of their machinery in language that can be understood by the nontechnical man, they will save their own service men many long useless rides.

To illustrate what is meant, reference is made to the temperature guarantees on motors given by manufacturers of electrical equipment. The gist of them is about as follows: "The temperature rise shall not exceed 40 degrees centigrade above the ambient temperature when operated at full load continuously." Have you ever tried to explain exactly what this means to a pumper who thinks that he has an overheated motor on his hands and is afraid that he will lose his job if it burns out? It is suggested that in addition to the above specification it will be very helpful to define the maximum temperature at which a motor may be operated. Why not state on a card attached to each motor: "Some of the materials used in insulating the wires on this motor are made of cotton that will char and crumble at a temperature slightly greater than that of boiling water. If one cannot hold one's hand on the stator iron until four is counted the interior of the motor is approaching a dangerous temperature." The ambient temperature in August in a well house located on a sand bank in East Texas is evidently a much greater quantity than it is in the month of January in one located on the Sky Line Drive of the Salt Creek, Wyoming field; but precisely what does the term ambient mean? One will be surprised to find out how many do not, that should, know. As for the use of the centigrade scale, it is simple to those of us who understand it but there are few nontechnical men who can think in terms of centigrade degrees, though the scale has been used by manufacturers for several decades.

The pumper who is confronted with an electrical installation for the first time is inclined to be afraid of it. He should be made to understand that there is nothing out of the ordi-

Individual electric motor powered, twin-crank, pumping jack equipped with reduction gear unit

nary to fear; that according to statistics, operating an electric rig is quite safe. As a matter of general information, insurance companies do not penalize policyholders who handle electric wires that carry alternating current up to 250 volts or direct current up to 600 volts. While 440-volt alternating current, the standard used in oil fields, is classified as a dangerous voltage, there is no occasion for operators to touch live circuits. The idea somewhat prevalent that electricity will reach out and shock unsuspecting passers-by is not founded on fact. A sheet of dry note paper will insulate one against 440 volts and one cannot feel 110 volts if the skin of his hand is dry. One does not go around touching uninsulated steam pipes with his bare hands and why should one touch the bare parts of an electric circuit? Safety is based on the principle of keeping one's hands off things with which one has no concern.

The danger associated with a 440-volt circuit or with one carrying a lower voltage all depends on how a victim is associated with the circuit. According to Tulsa, Oklahoma, newspapers, three men have been electrocuted in that city on 120-volt alternating current during the last two years. In all cities it is the accepted practice for power companies to ground one wire of their lighting circuits and, strange as it may seem, this practice evidently caused the men's death, assuming that they were electrocuted. In each case the victim was well grounded and had grasped the ungrounded wire or a metal part touching this wire. In the most recent case it is said that the man was under a building with the back of his head against a water pipe when he bared an ungrounded wire. The practice of grounding one wire is to remove the hazard that occurs when high tension wires are crossed up with the low-voltage wires during a storm, or when the insulation of a transformer is defective. Evidently statistics indicate that the practice is the lesser of two evils.

The cases cited above and numerous observations made in the oil field lead the writer to conclude that grounds on low-voltage electric lines introduce a hazard to both life and property. Frequent tests should be made on oilfield lines and when a ground does show up it should be located and removed without delay. In practice, on modern installations the construction is such that the hazard to men is almost negligible. However, it is a good plan to locate all apparatus, such as disconnect switches, line starters and kindred appliances high on the wall of the motor house so that the weight of a man's body will act to remove him from the circuit in case he does come in contact with the live part of a switch on a grounded circuit. Safety switches are only safe when the automatic locking device is left intact and it is not uncommon to find one that has had the locking device removed.

In case it is necessary to make minor repairs to the wiring such as taping up a worn place on a cable or tightening up a stud that holds a terminal to a switch one should stand on a dry board or on an old inner automobile tube. Clean dry cotton gloves may be worn as an additional precaution. Treated fabric tape, not rubber tape, covered with a layer of friction tape should be used on cables that are likely to be exposed to oil. Every one who works about an oil field should be taught to recognize the primary and the secondary wires of a distribution system and to understand that the former are taboo.

The fuses in the disconnect switch should be regarded as a protection for the rig as a whole rather than as a protection for the motor against overloads. There is a possibility of short circuits occurring in the wiring of the rig due to lightning discharges or other causes that line starters will not handle. Under no conditions should wire, metal bars or similar devices be used for fuses. It is not good practice to use fuses of different ratings as one fuse may go out and allow a motor to operate on a single phase, thus throwing an excessive load on a part of the winding. In certain instances small pumping motors were known to have been burned out by this action when some one stole one of the fuses while the rigs were running.

The most common device in use for protecting pumping motors against overloads is a contrivance for opening the circuit of the coil that holds the fingers of the magnetic switch in contact. These are operated by the heat of a resistor through which the load current passes. Sometimes people forget that the heat produced by the Texas sun when added to that of a small load current will cause these temperature relays to operate. On numerous occasions reported mysterious overloads were found to be due to this cause.

For reasons evident to anyone who remembers this possibility, care should be exercised in locating the starting switches. Another thing, in the matter of choosing the location of starting switches, it should be remembered that gas usually stays close to the ground so the fire hazard is less when line starters are mounted high on their supports.

On installations on which anti-friction bearings are used, pumpers should be taught to follow the directions given by the manufacturers. Too much zeal in inspecting these bearings and in adding lubricant before it is needed does more harm than good. As a rule any trouble that does develop appears during periods of cold weather when the grease becomes thick and does not spread properly.

Nothing but a good quality of motor oil should be used in motors having sleeve bearings. The sealed sleeve bearings now in common use give much less trouble than the old type semi-open bearings. Pumpers are more apt to use too much oil than too little. Ordinarily a glance at the overflow cups will indicate the level of the oil. When oil is to be added or the oil is to be changed the rig should be shut down so that the oil on the shaft and that carried by the rings will drain back into the reservoir and the actual level can be determined. Otherwise too much oil is likely to be added and when the rig is stopped the oil reservoirs will overflow. Oil should be introduced through the overflow cups and not through the slots in the top of the bearing. One should learn tc recognize instinctively the metallic clinking sound that an oil ring makes when the oil is low. In starting up new motors or motors that have been moved it is wise to check the oil rings and make sure that they are in their places and are turning. Sometimes they lodge on top of the bearing and cannot rotate.

On belted jobs excessive belt tension is the source of much of the trouble that occurs, for the tendency is to run belts too tight. In general belts should be run just as loosely as they will carry the load without slipping at some point in the stroke. The introduction of V-belt drives has eliminated much of the trouble previously prevalent on motor pulleys of a small diameter.

The air gap, that is, the clearance between the rotor and the stator of a motor, is by nature small. In case the bearings become worn and the rotor drags on the stator iron, the windings are likely to be injured. In order to anticipate this trouble spacing gauges should be provided so that the clearance can be checked from time to time. It does not take an expert to do this and it will frequently save a rewinding job. When motors are new the air gap should be uniform around the entire periphery, but as bearings wear the gap at the top will increase and that at the bottom decrease. Any wide range in uniformity should be the signal to order a set of new bearings.

If motors are to have a long active life they should be kept clear of dust, free from oil, gasoline, naphtha and similar substances that some operators are in the habit of using for cleaning; and of course the windings should be kept dry. A good hand bellows may be used occasionally to blow out the sand, lint, and dust of any nature that restricts the free movement of the air through the winding and the ventilating ducts.

The horsepower rating of a motor is based on three things —mechanical strength, excessive drop in speed and the increase in temperature. The first factor need not be given any consideration in practice and the second very little since all such motors are provided with more torque for starting the load than is needed for them to carry their operating load. The third factor, that is, the temperature developed, always determines the load a pumping motor will carry. It is evident that anything that will increase the rate at which heat can be dissipated will increase the possible rating of a given motor. A motor enclosed in a small tight building, one that has a box put over it to keep out foreign material or one that has been made drip proof, splash proof or rain proof will not carry its rated horse power if it has been rated truthfully as an open motor. The system used by manufacturers in rating a given motor at the same horsepower when it is open and its ventilation is good as when it is made rain proof and the ventilation is greatly reduced is likely to cause them grief when loads increase so that the full rating is required. It is true that one is guaranteed for an increase of 40 deg. C. and the other for an increase of 50 deg. C. but it will save them trouble in the end if they will state on the tag suggested above that a 25-hp. motor is, we will say, only a 21-hp. one when made splash proof. This may not be the exact reduction but it illustrates what is meant.

Cotton insulation is said to char at a temperature of 105 deg. C. or 221 deg. fahrenheit. Much needless work and worry will be eliminated if some method were developed whereby a pumper can determine, not the actual temperature of a motor but whether the interior of it is below a safe temperature. One electrical manufacturer has a device on the market that can be modified so that it will perform this operation and another manufacturer does the same work on other apparatus in another way. It appears that either of these devices if perfected so as to give an optical or an audible signal, will perform a needed service and will be welcomed by the trade.

Another device that should be in the pumper's hands is an indicating ammeter for checking the counterbalancing of wells. An ammeter with the needle located in the middle of the scale so that it can swing either way is preferable and a flexible cable equipped with a plug for inserting into a jack should be provided. In order to use the meter one of the line wires leading to each motor should be equipped with a jack so that all one needs to do is to plug in on the load circuit. The source of much trouble is the improper counterbalancing of wells and various systems are being recommended but after the novelty of a new installation has worn off and the field settles down to pumping, the ammeter will be the one device that will be used. It is accurate enough for all ordinary purposes, is easy to use, and is safe and effective in the hands of a novice. It should be kept in mind that power current peaks and reverse power currents due to overbalancing are equally objectionable.

In the final analysis of a rig a few load observations made under the direction of an engineer under known conditions will enable the average man to recognize instinctively certain conditions by the whine given out by a motor. Every type of motor has its particular note under load; one variation will mean that the well is under-counterbalanced, another that there is reverse power due to over-counterbalancing, another that the weight has been advanced or retarded. Once he has scented it, an operator should recognize the smell of an overheated motor though his mind is on something else. One will be agreeably surprised to find out how much electric service work an intelligent pumper will be able to anticipate when he has been given even a limited amount of instruction, in language that he can understand.

New Oil Well Pumping Practice I of Small Gen e

Gas engines driving electric generators supply power for pumping small number of oil wells

THE first installations of several small central plants, each consisting of a gas-engine-driven generator for supplying electric energy to pump a small number of oil wells have recently been made in the East Texas field. These small generating plants are of special interest to oil operators, since they introduce something new in modern oil field pumping practice. Data obtained under field operating conditions indicate a high efficiency. These pumping power units have many advanced operating features, among which are control for either automatic or manual starting and stopping, provisions whereby the individual well motors may be changed instantly to either of three different horsepower ratings. In addition, they are installations of the outdoor type entirely with the exception, of course, of a small building that houses the prime mover, generator and master control panel.

The Stanolind Oil & Gas Company has or will have installed a total of 12 of these units in the East Texas field. Cox & Hamon have two electric power generating plants installed for pumping wells. On an average these generating plants are being depended on to provide current for pumping only six wells. Since this is the first time generating plants have been built to pump such a small group of wells, their mechanical hook-up and operating features are highly interesting.

Description of Equipment. Each generating plant, as being installed by the Stanolind Oil & Gas Company, consists of a 165-hp., twin-cylinder, 16-in. by 20-in., type G-DT (EC) Cooper-Bessemer gas engine, a type ATI, 125-kva., 100-kw. at 0.8 per cent power factor, 480-volt, 3-phase, 60-cycle, General Electric generator, a General Electric exciter and a master control panel.

This generating equipment is housed in a sheet-metal building, with concrete floor and concrete foundations for all machinery. The engine has been placed in the center of the housing, with the generator and exciter set directly behind the prime mover. The master control panel is installed in one corner of the building.

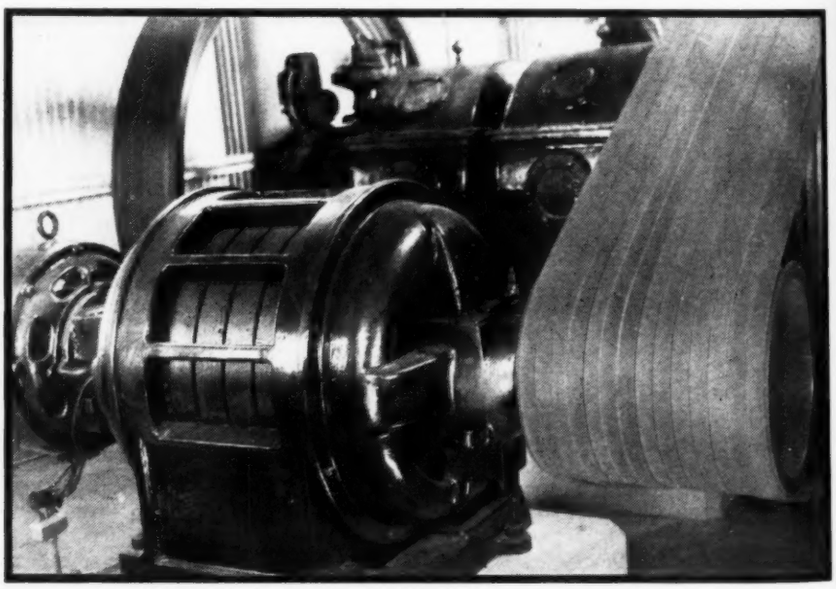
Auxiliary equipment in the generating house includes a circulating water pump driven by a flat-belt driven from a small pulley on the engine shaft and a Cooper-Bessemer air-compressor that is capable of building up 250-lb. air pressure. The air compressor is used for starting purposes only.

The equipment at each well is composed of a control board; a type KF, 25/15/9-hp., 1800 r.p.m., 440-volt, 3-phase, 60-cycle, ball-bearing, low-starting current type General Electric motor with splash-proof and drip-proof covers suitable for outdoor use in East Texas; an Emsco-Falk No. 10 MDS double reduction gear unit equipped with a flywheel, brake and an Emsco crank counterbalance with extra weights and with taper fit wrist pins. The steel Sampson posts and walking beams are L. C. Moore products.

Control Equipment. The design of the control equipment has been thoroughly engineered to obtain the desired flexibility in power requirements at the wells and to make the station both practical and efficient. All the control equipment is of the full voltage starting type and is arranged for automatic operation by means of time switches or for manual operation if preferred. It also provides a convenient method of changing horsepower ratings of the motors.

The master control panel includes a carbon-pile type voltage regulator; an A.C. ampere meter; an A.C. volt meter; an electric clock; a concentric rheostat operating mechanism for operating generator field rheostat and exciter field rheostat when manual adjustment is desired; two type FK-20 oil switches each controlling one feeder circuit; and a watt-hour meter that tells how much energy the generator has provided over any given time. The usual practice is to connect three wells to each feeder circuit.

The individual well control board includes a type T13 time switch that allows almost any time setting for on or off operation; a combination fusible entrance switch and magnetic starting switch; three plug boxes and a transformer to provide 110 volts for emergency lighting at the well and also for operating the time switch. These control panels are protected from the weather by a metal box container. The



Generating equipment in Stanolind Oil & Gas Company plant. Cooper-Bessemer engine in the background drives, through V-belt, generator in foreground

Introduced with First Installations

erating Plants

By BAILEY E. PRICE
Mechanical Engineer
Engineering Construction Co.
and
WARREN L. BAKER

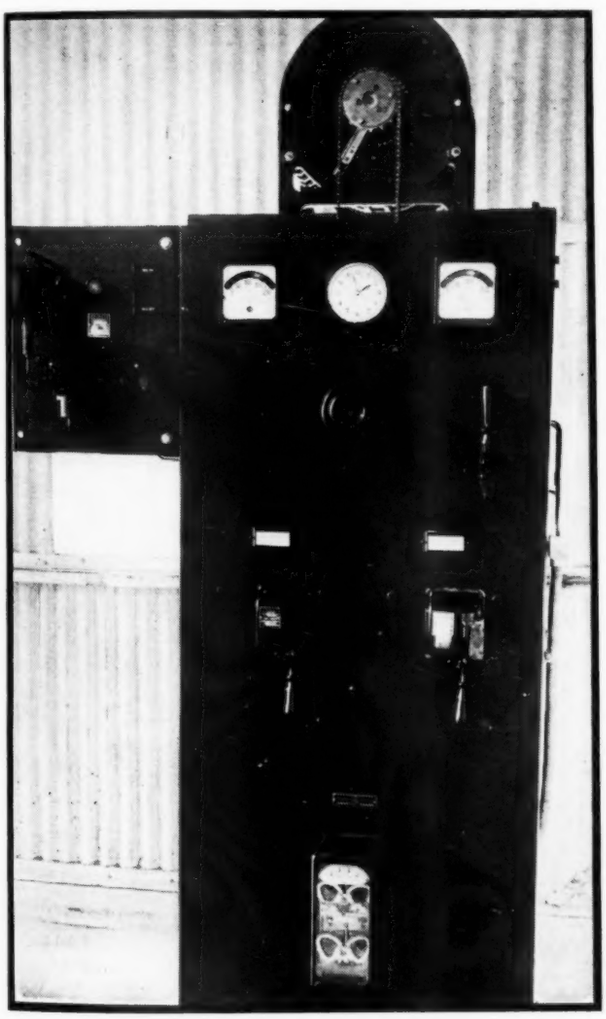
newer control panels, now being installed by Stanolind, will be provided with an outlet plug at the bottom for plugging in a trouble light.

General Operation. In the general operation of these plants the gas engine drives the generator through a V-belt transmission, an interesting feature of which is that the large drive pulley attached to the engine shaft has a flat face rather than the usual V-belt grooves. The generator is equipped with a regular sheave-type pulley. With this mechanical design the drive is surprisingly smooth in operation. The exciter is direct-connected to the generator.

The energy thus generated is carried to the individual well's control board through lead-covered, jute protective wrapped cables, buried 18 in. beneath the ground. By burying the cables to this depth it was believed that they would be deep enough to be safe from injury when laying any flow lines, etc., and therefore would not have to be disturbed. The size of the cables, depending upon the load, varies from No. 0 to No. 3.

The motor at the well transmits its energy through a V-belt drive to the gear unit. Since the motor is mounted on an adjustable steel base it is easy to keep the belt drive in proper tension at all times. It is possible to obtain a number of different pumping speeds by changing the size of the pulley on the shaft extending from the gear unit; the length of the stroke is governed in the customary manner by adjustments on the wrist pin.

At the present time these units have not been tested under normal field pumping conditions, but they were recently subjected to a test probably more severe than will be encountered under actual field pumping loads. All the wells, six in number, on the Stanolind's Mason lease, near Carlisle in the south end of the field, were equipped with 3500-lb. counterweights but not connected to the walking beams. Under this condition the equipment was subjected to an uncounterbalanced load. A problem in the operation of stations of this type is that of starting full-load motors. However, these tests demonstrated that the units are capable satisfactorily of handling this difficult problem. When five wells were being operated on the 25-hp. side of the motor, during this test, it was possible to start the sixth and for it quickly to reach its full speed. The equipment also successfully withstood the load of having two motors started simultaneously.



Master control panel
located in generating room

Pumping Features. The use of triple-rated motors assures the company of ample power to handle all pumping requirements without the loss of any motor efficiency. These motors have an efficiency of 80 to 90 per cent within the whole range from 4½ to 25 horsepower. At the present time, pumping requirements of the field do not exceed five or six horsepower, but it is anticipated that it may exceed 20 hp. during the later pumping stages. The Stanolind does not propose to use these motors for pulling operations.

The individual well control panels are one of the most interesting features of the installations. The three-plug boxes permit instantaneaus changes in the horsepower ratings of the motor. Two of the box covers are "dummies," while the other is an "active" one, as indicated by the word "on" imprinted upon its face. The "active" plug in use, inserted by the operator, determines the horsepower rating of the motor.

The electric time switch provides almost any time setting for on or off operation. It may be easily arranged, by changing the indicating hands, to pump for as short a time as 15 minutes or for any period up to 24 hours continuously or periodically.

A number of wells where these installations are being installed are in hilly territory, parts of which are swampy. The use of buried cables simplified the problem of connecting the wells to any desired power; and the use of the automatic features relieves the pumper from making short periodical trips to each well during the high water seasons.

The Viscosity Temperature Susceptibility Coefficient

By H. G. NEVITT
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White Eagle Oil Corporation

The First of Two Articles on This Subject

VISCOSITY is a well known and frequently used characteristic of liquids, particularly of lubricants, paints, and binders. Experience has shown that generally where viscosity is of importance, its value at more than one temperature must be considered. That is, of equal importance with the value of the viscosity at any one (or standard) temperature is the rate of change with temperature. The viscosity characteristic is essentially a two-dimensional quantity, only completely defined by both the value at a standard temperature, and the rate of change from that temperature.

Much attention has consequently been paid in recent years to viscosity-temperature relationships. These studies have been primarily on the hydrocarbons, in the lubricating oil range, due to their common use and the importance of the viscosity-temperature characteristic in internal combustion engine lubrication. Such compounds should be relatively simple, showing few tendencies toward colloid formation, association, change of state and so on in the usual working range. Consequently similar action from like compounds could be anticipated, making this field an ideal one in which to develop the fundamental viscosity-temperature relationship for simple compounds, if one exists.

Many viscosity-temperature data have been collected and analyzed.[4] The viscosity of liquids tends to decrease rapidly with increase in temperature. This logically follows from the cause of viscosity, i.e., resistance to internal shear in the liquid due to molecular friction. Heating the liquid tends to increase the space between the molecules, decreasing the internal friction. Since intermolecular volume is zero at absolute zero temperature and increases with increase in temperature to vaporization, change of viscosity with temperature should properly be compared on the basis of absolute temperature.

In order to analyze, evaluate, and use viscosity-temperature relationships in a completely general way, a fundamental relationship or expression between viscosity and temperature applicable to any liquid is highly desirable. This relationship, being an important function, should be measurable and expressible in definite units for comparison. The expression for the relationship should be as simple as possible, and have a simple and readily understandable physical meaning. The scale of measurement should be reasonably uniform, so that two products the same in this characteristic would have the same measurement although different in other ways. This would mean that it would be applicable to different classes of products, as the viscosity-temperature criterion should be independent of the viscosity or temperature.

Lack of some of these desirable features is an objection to many criteria either proposed or in use. When used over a very limited range they may make an excellent standard of comparison, yet have little or no meaning out of it. For example, some methods of evaluating the viscosity-temperature characteristic in lubricating oils cannot be applied to fuel oils having the same relative interrelationship. It is highly desirable to express the same relative viscosity-temperature trend of a series of related products according to the same measuring stick and not have a different scale for each particular (and narrow) field.

Generally the proposed relationship has been sought or suggested in graphical form. A desirable type will permit plotting the data, if necessary, to scales of special character based on the interrelating equation between viscosity and temperature, and getting a simple curve, preferably a straight line. Such graphical relations are easier and simpler to use, and make it no more difficult to express the data for a complicated relationship than for a simple one. While the equation adopted is of interest, it must be susceptible to this graphical treatment to be adopted in practical use. It is even possible to make such a chart without expression of the equation represented, though all so far studied have apparently determined a scale empirically that has been expressed mathematically by others.

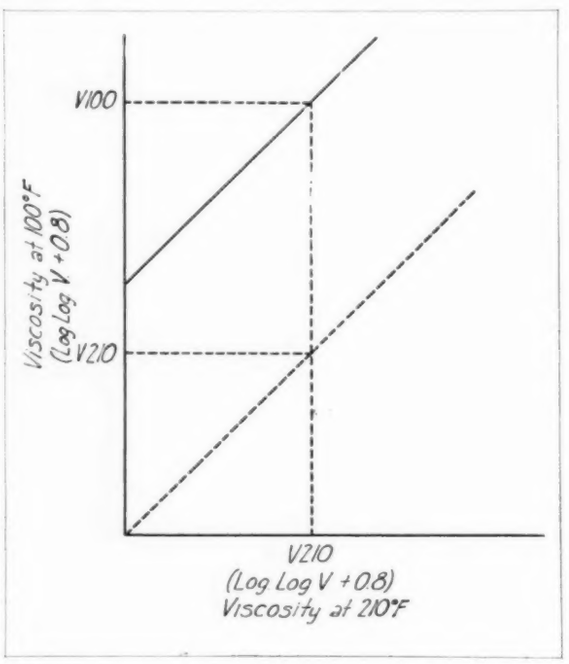


Fig. 1—Mathematical relationships of V.T.S. determination chart

Proposed Viscosity-Temperature Relationships. Evidently a fundamental general relation between viscosity and temperature could not be expected to appear in the ranges where molecular association, crystallization, or similar changes of state occur. However, such has not yet been found, although possibly existing, over the entire range on simple products that presumably show nothing more than increased molecular energy and increased specific volume with in-

crease in temperature. A few of the more valuable relationships proposed will be briefly discussed.

The relationship:

$$V^a T^b = C \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad \text{Equation 1}$$

indicated by a straight line when plotting log viscosity V against log absolute temperature T, holds fairly well over a narrow range but is not sufficiently accurate over the entire scale to indicate a true relationship or compete with other more accurate relations, though useful for less accurate work as well as certain general purposes, as shown by Genereaux.[3]

Vogels equation:[4]

$$(V - A)(B - T) = C \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad \text{Equation 2}$$

as an approximation that suits the general trend of the data. With three independent equational constants it can be fitted very closely to any material over its usual working range, yet this does not necessarily indicate that it expresses the basic relationship involved. It is also unsuitable for graphic use, which is probably sufficient reason for its lack of widespread acceptance. For general graphic use one of the constants A or B must be taken the same for all products, as was done by Sloane and Winning,[11] greatly lessening the suitability of the equation. Whether or not, when this is done, the equation will be useful over a wide range is not known; the data in the literature are not sufficient for a final conclusion.[3]

The equation:

$$\text{Log } A\ (V + B) = K\ T^e \quad . \quad . \quad . \quad . \quad . \quad \text{Equation 3}$$

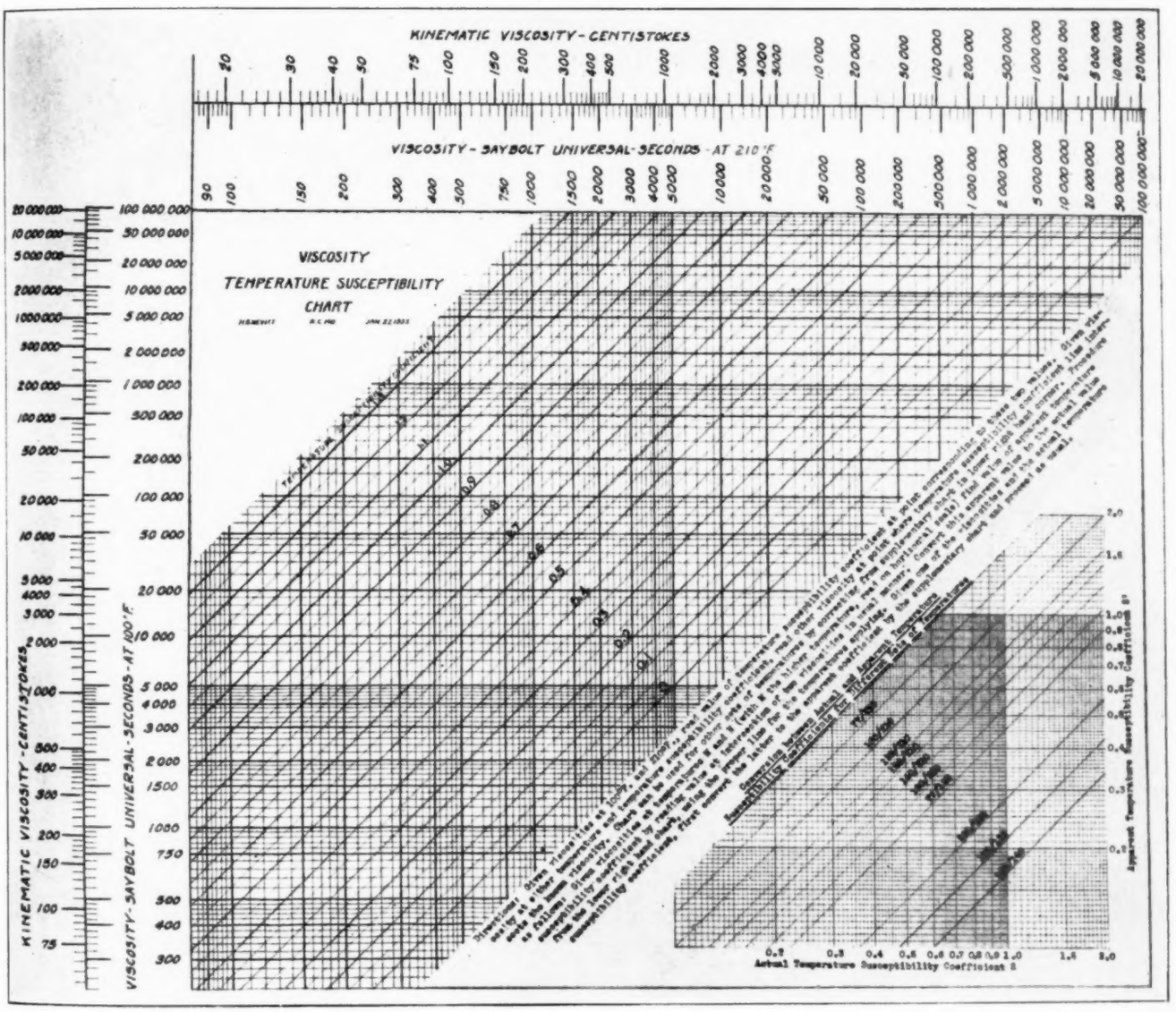
has received the greatest attention in industrial research studies. It is the basis for the plotting chart recently issued by the American Society for Testing Materials (A.S.T.M. Tentative Standard D341-32T). In this chart A has been taken as unity for V expressed in centistokes, with $B = 0.8$, leaving C and K as the two constants determined by the particular product. Study by the committee previous to issuing this chart indicated that most of the data available gave straight lines when plotted on this chart. Since some earlier charts which were made with empirical scales for viscosity appear to have practically the same relation it may be said that this equation is the only one in general use today over a wide range of viscosities. It will be discussed in more detail later.

Another proposed relation has been:

$$\text{Log } V = A + (B/T) \quad . \quad . \quad . \quad . \quad . \quad \text{Equation 4}$$

The writer is not familiar with this relation in actual use, but believes it suffers from the same objection as most of the other relationships, of only giving straight lines over a narrow range. The reciprocal absolute temperature function has apparently been suggested by some theoretical relations in thermodynamics, with application to viscosity by analogy. It will be noted that this equation is simply a special and simplified form of the more general and previous one.

Chart 1—Viscosity Temperature Susceptibiltiy Chart. Viscosities at 100 deg. fahr. and 210 deg. fahr.


KINEMATIC VISCOSITY - CENTISTOKES
VISCOSITY - SAYBOLT UNIVERSAL - SECONDS - AT 210 °F
VISCOSITY
TEMPERATURE SUSCEPTIBILITY
CHART
KINEMATIC VISCOSITY - CENTISTOKES
VISCOSITY - SAYBOLT UNIVERSAL - SECONDS - AT 100 °F.
Apparent Temperature Susceptibility Coefficient S'
Actual Temperature Susceptibility Coefficient S

The viscosity index, while not a fundamental equation, is another method in use today of evaluating the viscosity-temperature characteristic.[1,2,8,9,10] It expresses the relation between the change in viscosity of the oil from one established temperature to another as compared to the changes of two other oils adopted as standards, one a representative paraffinic or low-temperature susceptibility oil, the other a representative napthenic or high-temperature susceptibility oil, both of the same viscosity as the oil in question at the higher of the two standard temperatures. That is:

$$V.I. = [(L-U)/(L-H)] \times 100 \quad \text{. . Equation 5}$$

where

V.I. = Viscosity Index

U = Viscosity (Saybolt-Universal) of the oil in question at 100 deg. fahrenheit.

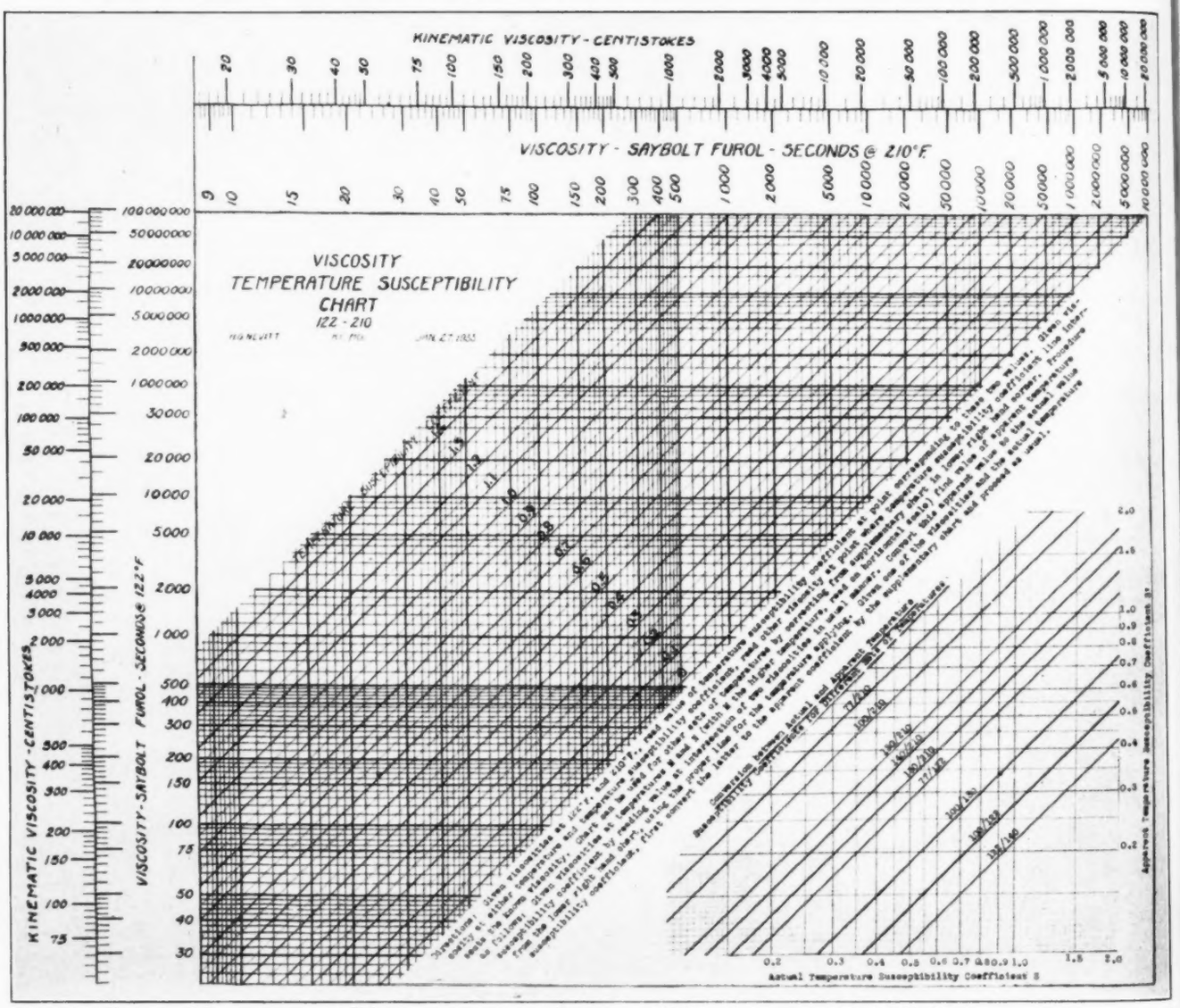
L = Viscosity (Saybolt-Universal) at 100 deg. fahr. of the naphthenic standard oil of the same viscosity at 210 deg. fahrenheit.

H = Viscosity (Saybolt-Universal) at 100 deg. of the paraffinic standard oil, of the same viscosity at 210 deg. fahrenheit.

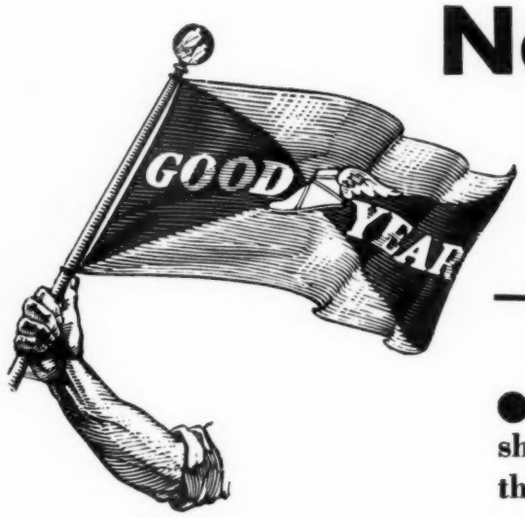
The viscosity index is evidently very empirical in nature, and so far applicable only in the relatively narrow range of viscosities covered by lubricating oils. Being a relative standard, with a convenient scale, it is very suitable for the constant (particularly commercial) worker with these oils, as it gives him the comparative status of the oil in question referred to similar products. For scientific or technical use it may have disadvantages. The comparison standards, that is the oils of varying viscosity against which the test sample is compared, may not have the same viscosity-temperature characteristic throughout the range studied, having been arbitrarily chosen. This appears quite probable from Chart No. 4 described later (Chart will be shown with concluding article next month). Consequently oils of the same viscosity index but of different viscosities may not have the same viscosity-temperature characteristic on an absolute scale. A further possibility is that later changes in manufacture and/or commercial products may change this tendency of selected standard oils to vary in their absolute viscosity-temperature characteristic, so that the convenience of the viscosity index as a comparative standard may disappear unless a new series of L and H standards are chosen. Other than the present convenience, the viscosity index does not seem to offer anything that cannot be obtained from a more logical, general, and universally applicable criterion of the viscosity-temperature characteristic.

Formulae for the viscosity-temperature relationship other than the above have been proposed, but do not yet have application to industrial problems.[4] They are either essentially variations or specific cases of the general formulae previously discussed, or are complicated equations that hardly seem to

Chart 2—Viscosity Temperature Susceptibility Chart. Viscosities at 122 deg. fahr. and 210 deg. fahr.


KINEMATIC VISCOSITY - CENTISTOKES
VISCOSITY - SAYBOLT FUROL - SECONDS @ 210°F.
VISCOSITY
TEMPERATURE SUSCEPTIBILITY
CHART
122 - 210
KINEMATIC VISCOSITY - CENTISTOKES
VISCOSITY - SAYBOLT FUROL - SECONDS @ 122°F.
Actual Temperature Susceptibility Coefficient S

NEW TIMES



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express the true relationship even though closely fitting the viscosity temperature curve found by experiment due to numerous constants in the formula. The only relation that at present seems of practical interest to the general user of viscosities is the relation 3, either used directly as by the A.S.T.M. chart, or in equivalence through empirical construction. This will consequently be discussed in some detail.

The A.S.T.M. Viscosity-Temperature Chart. In developing the A.S.T.M. diagram, it was stated that the great majority of oils plotted on it gave straight lines. The few that did not might be explained as exceptions to the normal viscosity-temperature relationship due to causes inherent in the material rather than the diagram.[5] For example, colloidal substances, which do not exhibit the same viscosity characteristics as true liquids when the rate of internal shear is changed, might also not show the same viscosity-temperature characteristics as true liquids. Even though this is correct and accounts for variations in the range of the A.S.T.M. chart as noted, there still seems some question whether the relationship used in this chart, with the constants selected, is exactly applicable over the entire range of viscosities encountered, and whether it consequently represents the theoretically correct relationship.

While no great study was made of this question, several things point to the conclusion just stated. First, viscosities below 0.2 cannot be plotted on any extension of the chart. Second, viscosities above this, but of very non-viscous materials, such as pentane, hexane, etc., seem to give curved rather than straight lines on the chart if extended to a sufficiently low range. Also these non-viscous paraffinic compounds give lines of considerable slope in addition to some curvature. This is contrary to the situation shown in the usual working range of the chart, where the more paraffinic the material the less the slope of the viscosity-temperature line. Probably Equation 3, properly to represent the true relationship, should have a further term or factor that has a negligible effect in most of the viscosity range covered by the chart but becomes appreciable as the viscosity becomes small. Such term is presumably a function of the viscosity primarily. The effect of changing either A or B to attempt to correct this is to cause curvature in the middle and upper range of the chart. Whether Equation 3 as written is simply an approximation of the true relationship applicable only in the indicated range, or with the suggested additional factor, would truly represent it and make the equation usable at all values, cannot be stated. It seems probable that an empirical modification of Equation 3 by such a factor could be found to take care of the situation for practical purposes.

Whether or not the simple equation for this chart as now used is the theoretically correct one, or whether or not it can be modified to cover a wider range, it still remains the best medium for expressing and evaluating viscosity changes due to temperature in the range of the chart. In general most liquids in which viscosity is of major interest can be handled by it. Probably any new equation, or modification of the present one to cover a wider range will not make inapplicable the chart as issued, or data developed from it. The primary purpose of this discussion has been to develop the apparent situation regarding the wider application of Equation 3, forestalling any difficulties that might arise in an attempt to evaluate the viscosity-temperature characteristic of low viscosity liquids.

The Viscosity-Temperature Susceptibility Coefficient. Adopting the A.S.T.M. chart of the range covered, and assuming that viscosity plotted against temperature on it will result in a straight line, a very simple evaluation of the viscosity-temperature characteristic or susceptibility of the viscosity to variation with temperature, is possible. The intersection of such line with a standard temperature abscissa, i.e., the viscosity at this standard temperature, and the slope of the line will completely define the viscosity of the material at any temperature. The fact that analogous materials, such as from the same source of the same composition, and given the same treatment, have closely the same slope further suggests the use of the slope measurement as an evaluator of the temperature susceptibility characteristic. Its use will then result in the same figure for similar products, whether lubricants, asphaltic residues, or similar provided they are in the range of the chart and actually similar in viscosity-temperature characteristics.

The tangent of the angle of slope of the viscosity line on the A.S.T.M. chart was consequently chosen as the indicator of the viscosity-temperature characteristic, and termed the viscosity-temperature susceptibility coefficient (V.T.S.C., or more briefly, the V.T.S.). The slope tangent of the actual line plotted on the chart was selected in place of the exponent C in formula 3, which is proportional to it, for several reasons. Viscosities, and the above formula, are usually handled graphically. Consequently, a simple graphical concept, with a quickly appreciated meaning, seemed desirable. The V.T.S. is in a convenient numerical range, as the majority of oils seem to have a V.T.S. around unity. The exponent C can be readily found from the V.T.S. by multiplying by the constant factor 4.52, but has little interest to practical users of the chart or viscosities. It might be noted here that to define the viscosity characteristic of a liquid by two numbers, each entirely independent of the other, the temperature characteristic must be proportional to, or a function only of, the exponent C alone. This follows from purely mathematical considerations, as long as Equation 3 holds.

This method of evaluating the viscosity-temperature characteristic seems at present best to satisfy the requirements of such a measurement as earlier outlined. Along with the viscosity at standard temperature the V.T.S. completely defines the viscosity relations of the material. It is a convenient measure to understand and use. As long as Equation 3 holds it indicates the temperature susceptibility independently of the viscosity, consequently is applicable to the wide range of oils covered by the chart — lubricants, residuals, etc. Finally, it is a type of measurement that adapts itself to further simplification and graphical methods in actual use as will be later shown.

The uses of the A.S.T.M. chart, and the V.T.S. as defined in connection with it, are obvious. Research work may call for the actual viscosities at various temperatures, finding the effects in use of oils with certain viscosities at a standard temperature, with varying temperature characteristics; and similar. The manufacturer will be more concerned with the classification of his products according to the relations so developed; that is, viscosity and susceptibility standards that will give results established by research or set by specifications. Given two viscosities at different temperatures, he will wish to know the temperature susceptibility coefficient, particularly as this is closely constant for the whole group of oils of that type. Again, with an oil of known temperature susceptibility characteristics and known viscosity at one temperature he will wish to know viscosities at other standard (specification) temperatures.

NOTE: The second and concluding article by Mr. Nevitt on this subject will appear in the December issue. It will contain the remaining charts, as well as references for both articles.—*Editor.*

Engineering Fundamentals Department

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W. L. NELSON
K. C. SCLATER
Editors

Elements of Applied Petroleum Refining

Article I
RAW REFINERY STOCKS

By W. L. NELSON
Professor Petroleum Refining
University of Tulsa

ONLY three groups of raw stocks are generally processed in the refinery. All refiners process crude oil; most of them process the vapors from crude oil and gasoline storage tanks and from cracking plants; and a few process natural residuums or bitumens.

Crude Oils

BASES

Physical Properties. Crude oils range widely in properties and composition from light crudes containing over 50 per cent of gasoline to nearly solid crudes that may contain no gasoline at all. Some of these solid crudes are considered as natural asphalts or bitumens. While crude oils cannot be divided into exact groups, the classification of (1) Paraffin Base, (2) Intermediate Base, (3) Hybrid Base, and (4) Naphthene Base (Asphalt Base) is useful. Mixed base oils are the same as intermediate base oils, although hybrid base oils are sometimes erroneously classified as mixed base because they contain wax. No two crudes are exactly alike, and many crude oils cannot be properly placed in any of the above four groups because they partake of the properties of two bases. The base of an oil may be determined by several methods:

1. *Bureau of Mines Key Fraction No. 1.*[1]—If the part of the oil boiling between 482 deg. fahr. and 527 deg. fahr. has an A.P.I. gravity of 40 or more, the crude would be classed as paraffin base, while if the gravity is 33 or less the crude is naphthene base.

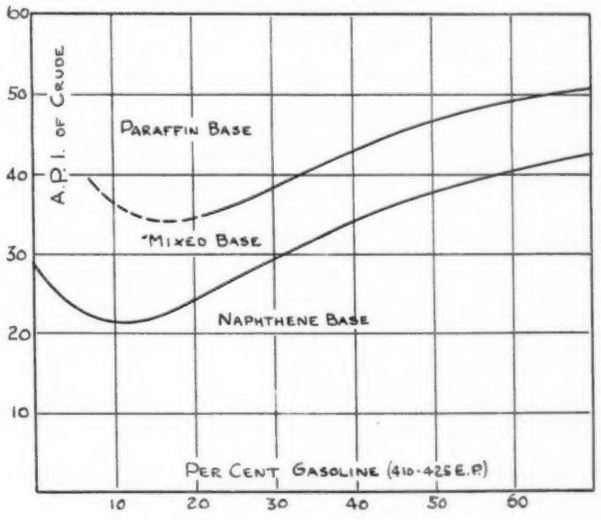
2. *Bureau of Mines Key Fraction No. 2.*[1]—The cloud point of the part or fraction boiling between 527 and 572 deg. fahr. at a pressure of 40 mm. is determined. If the cloud point is below five deg. fahr. the crude contains substantially no wax and would be a typical nephthene or asphalt base oil. Hybrid base oils are like naphthene base oils except that they contain no wax.

3. *Crude Gravity and Gasoline Content.*—This very useful method is presented in Fig. 1. Mixed base crudes (intermediate) fall between the two curving lines and paraffin and naphthene base crudes fall above and below, respectively. Thus a crude oil having a gravity of 37 and containing 32 per cent of commercial gasoline would be mixed base, while oils of the same gravity but containing 20 per cent and 50 per cent of gasoline would be paraffin base and naphthene base, respectively.

4. *Viscosity Index of Lubricating Oils.*—The viscosity of paraffin base oils decreases a relatively small amount when the oil is heated, whereas the viscosity of a naphthene base oil drops rapidly as the temperature is increased. The rate at which the viscosity of the lubricating oil decreases with temperature is measured by the Viscosity Index. This is discussed by Dean and Davis.[2]

Other methods are useful[3] such as comparing the distillation properties of the unknown oil with those of other oils but this requires a complete distillation. The lubricants from naphthene base oils have a characteristic blue fluor-

Fig. 1—Base of a crude oil



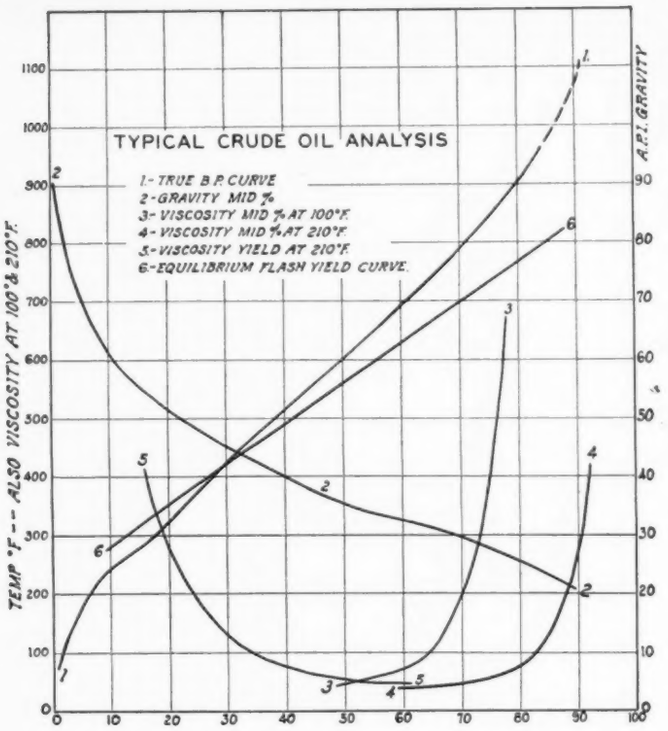

TYPICAL CRUDE OIL ANALYSIS
1- TRUE B.P. CURVE
2- GRAVITY MID %
3- VISCOSITY MID % AT 100°F.
4- VISCOSITY MID % AT 210°F.
5- VISCOSITY YIELD AT 210°F.
6- EQUILIBRIUM FLASH YIELD CURVE.
TEMP °F -- ALSO VISCOSITY AT 100° & 210°F.
A.P.I. GRAVITY
%

Fig. 2—37.3 A.P.I. mixed base crude oil

escence or cast while paraffin base lubricants have a yellow-green cast. This fluorescene can be best judged by viewing the oil in a thin layer against a black background.

General Processing. In general, the paraffin base raw products are the most easily treated, while the others follow in the order mixed base and naphthene base. This applies to the light distillates such as gasoline as well as the heavy lubricating oils. Naphthene base oils usually contain the most sulphur while paraffin base oils contain scarcely any sulphur. Paraffin and mixed base crudes contain wax and this must be removed in producing finished market products. The fact that naphthene base oils contain no wax simplifies the manufacture of lubricants if the manufacture is feasible from a treating standpoint.

These characteristics govern the methods of processing used for the different bases of oils and the products manufactured from them. Paraffin base oils are particularly suited for the manufacture of lubricating oils. The gasoline, however, knocks badly in modern automotive engines. Lubricating oils are also produced from mixed base oils, but acid treatment is usually necessary and hence the expense of manufacture is usually greater. Vacuum distillation is particularly adapted to the processing of mixed and naphthene base oils because most of the asphalt or tarry material may be left as a distillation residue of tar and the distilled lubricating oil stocks are more easily treated. Naphthene base oils contain the best asphalt and in quantities large enough to justify its manufacture. The gasoline from naphthene crudes is often highly anti-knock and may be sold directly as premium grade fuel. Large quantities of residual fuel oil and gas oil of mixed and naphthene base origin are sold, but most of the residue after skimming the gasoline and kerosene, is cracked into gasoline and cracked heavy fuel oil or coke. Cracking or pressure distillation consists in heating the residual oil at temperatures of 870 to 950 deg. fahr. under pressure with the formation of anti-knock cracked gasoline by decomposition of the residual oil charging stock. In this way the total yield of gasoline may be increased from about 30 per cent by topping to even 75 per cent by topping and cracking.

Distillation Curves. Typical distillation and property curves of the three common bases of oils are shown in Figs. 2, 3 and 4. The use of these curves is given in reference 3.

Yields from these curves are as follows:

	Naphthene	*Mixed*	*Paraffin*
Raw Gasoline 400 E.P. - - -	4.5*	29.0	33.5
Raw Kerosene—Yield - - - -	6.0	12.0	11.5
Gravity - - - - - -	37	43	45
Gas Oil (by difference) - - -	12.5	8.5	15.8
Wax Distillate 80 Vis. at 100° F.	14.0**	24.0	27.6
Steam Refined Cylinder Stock, 160 Vis. at 210° F. - - -	63.0	26.5	11.6
Temperature to vaporize Gasoline, Kerosene and Gas Oil in a pipestill without cracking -	640°F	598°F	543°F

*Not of proper boiling range for market. Really naphtha.

**A misnomer because it contains no wax.

In part these yields are misleading because the 63 per cent of cylinder stock in this naphthene base crude is a black tarry oil containing such large quantities of asphalt that the cost of treating and filtering would be almost prohibitive, and furthermore, the oil produced from it would have a poor viscosity index. In other words, the crude may not be suitable for the manufacture of lubricants. Not all naphthene base oils contain asphalt, but even the lighter colored ones require a large amount of acid and vigorous filtration. The mixed base cylinder stock also contains some tarry material so that acid treatment and filtration are necessary, but the paraffin base cylinder stock is fairly light in color so that filtration alone will produce a suitable color for marketing.

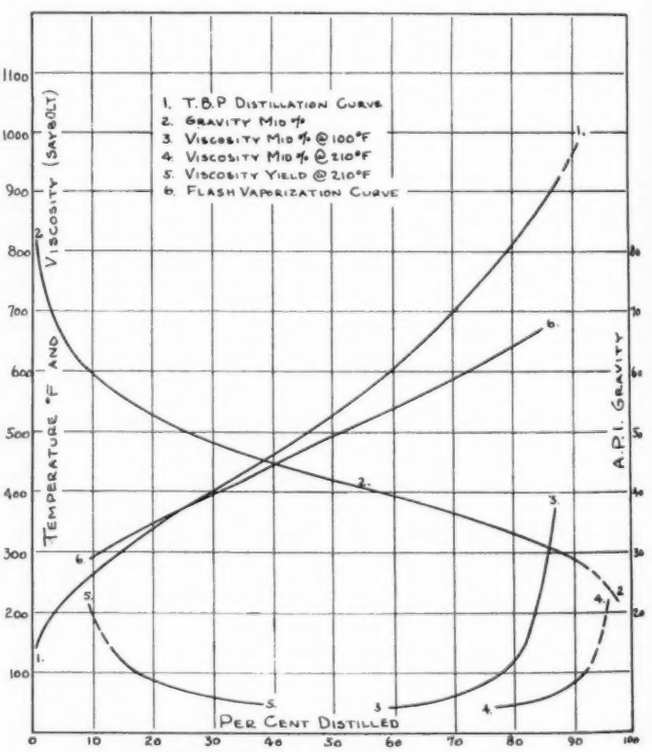

1. T.B.P. Distillation Curve
2. Gravity Mid %
3. Viscosity Mid % @ 100°F
4. Viscosity Mid % @ 210°F
5. Viscosity Yield @ 210°F
6. Flash Vaporization Curve
Temperature °F and Viscosity (Saybolt)
A.P.I. Gravity
Per Cent Distilled

Fig. 3—42.2 A.P.I. paraffin base crude oil

Refinery Gases

NATURAL GAS. Wet natural gas contains certain hydrocarbons that are suitable for incorporation into gasoline. Natural gas consists mainly of methane and ethane but propane, butane, pentane, etc., are also present in small quantities and these hydrocarbons are low boiling liquids that aid in causing an engine to start easily in cool weather.

CRACKED GAS. The vapors from storage tanks and the cracking units of a refinery are particularly rich in these hydrocarbons and hence the vapors are collected and the gasoline hydrocarbons in them are recovered as *natural gasoline*. Those gases that contain more than one gal. of gasoline per 1000 cu. ft. are generally considered as wet gases.

GENERAL PROCESSING. The general method of recovery today is by the absorption process. The gas or vapor is brought into contact with an absorption oil (light gas oil) in an absorption tower. The heavier hydrocarbons are absorbed preferentially and are removed from the rich absorption oil by heating the oil and stripping with steam. The gas that leaves the absorber contains little gasoline and is called dry natural gas. The details of the processing methods will be discussed in a later article of this series.

The composition of gases varies widely, depending upon the source of the gas. Typical analyses are shown in Table I. The quantity of natural gasoline that can be recovered from a gas can be computed from the gas analysis. The gallons of gasoline obtainable from 1000 cu. ft. (measured at 60 deg. fahr.) of each of the constituents is as follows:

Propane - - - - - - - - - -	26.6
Butanes C_4H_{10}, iC_4H_{10} and C_4H_8 - -	31.8
Pentanes C_5H_{12}, iC_5H_{12} and C_5H_{10} -	36.3
Hexanes C_6H_{14} and C_6H_{114} - - -	41.2
Hexanes and heavier - - - - - -	44. (average)

Thus the gasoline that can be recovered from 1000 cu. ft. of gas No. 3 is:

Hexanes and heavier $.0143 \times 44$	$= 0.63$ M gal./cu.ft.
Pentanes $(.0151 + .0276) \times 36.3$	$= 1.55$
Butanes $(.0444 + .0777) \times 31.8$	$= 3.89$
	6.07

Propane is a gas at room temperatures and is not recovered unless bottled gases, etc., which are sold in pressure cylinders for lighting and cooking, are to be manufactured. There is no sharp distinction between wet and dry gasoline from a gas containing only 0.5 gal. of gasoline (pentane and heavier) per 1000 cu. ft. while at other conditions a recovery of 1 gal. per 1000 cu. ft. may be economical.

QUESTIONS

1. What is the major difference between Hybrid and Naphthene Base crude oils?
2. What is the base of a crude oil having a gravity of 35 A.P.I. and containing 30 per cent of gasoline? Containing 20 per cent of gasoline?

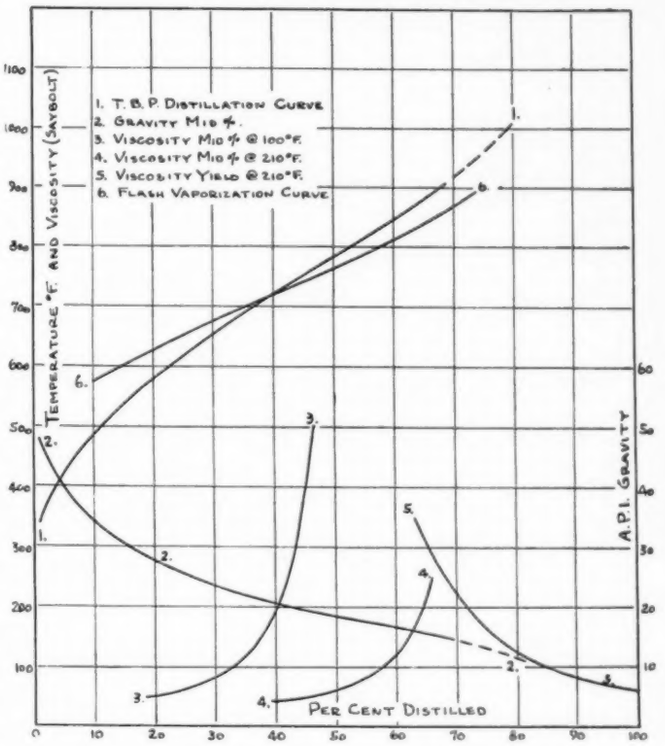

1. T. B. P. Distillation Curve
2. Gravity M10 %.
3. Viscosity M10 % @ 100°F.
4. Viscosity M10 % @ 210°F.
5. Viscosity Yield @ 210°F.
6. Flash Vaporization Curve
Temperature °F. and Viscosity (Saybolt)
A.P.I. Gravity
Per Cent Distilled

Fig. 4—20.2 A.P.I. naphthene base crude oil

3. For mixed base crude oils containing 30 per cent of gasoline, what is the range of A.P.I. gravity? (29.5—38).
4. What base of crude oil contains no wax?
5. In general, can a naphthene base gasoline be treated more easily than a paraffin base gasoline?
6. Give two reasons for the fact that paraffin base crude oils are usually processed for lubricants while naphthene base crudes are seldom processed for lubricants.
7. Consider natural gas No. 2 in Table I. How many gallons of natural gasoline consisting of pentanes and heavier can be recovered per 1000 cu. ft. of gas?

   How many gallons if the gasoline consists of propane and all heavier hydrocarbons? (1.08 and 3.9).
8. How many gallons of natural gasoline (butanes and heavier) have been left in the dry gas No. 1, Table I? (0.336).

References for a more complete study:

[1]Smith—"The Interpretation of Crude Oil Analysis," Bureau of Mines Hempel Method—Reports of Investigations, Serial No. 2806.

[2]"Viscosity Variations of Oils with Temperatures," Chem. Met. Eng. 36:618 (1929).

[3]Nelson—"Evaluation of a Crude Oil," The Petroleum Engineer, April, (1931).

[4]"Tabulated Analyses of Representative Crude Petroleums of the United States," Bureau of Mines Bulletin 291. Also Bureau of Mines Reports of Investigations, Serial Numbers 2807, 2202, 2335, 2322, 2290, 2293, 2364, 2416, 2595, 2608, 3130 and many others.

[5]Cross—"Handbook of Petroleum, Asphalt and Natural Gas."

[6]Beiswerger and Child—"True Boiling Crude Analysis," Atlanta meeting of Am. Chem. Soc.

[7]"Motor Fuels," by Leslie. Chapters II and III. Chem. Cata. Co. (1923).

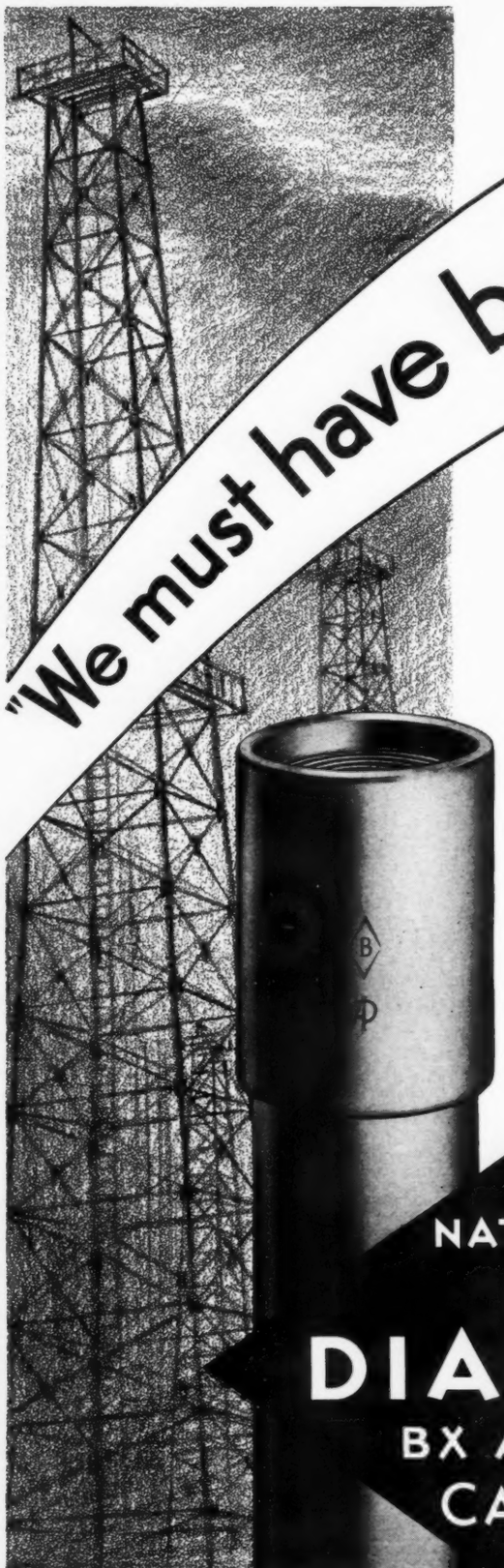
[8]"American Petroleum Refining," by Bell. Chapter II, 2nd Ed. (1930). Published by D. Van Nostrand Co.

[9]Nelson—Three articles, The Petroleum Engineer, April, February, May (1931).

TABLE I

Analysis by Volume (Measured at 60° F.)

	From		CH_4	C_2H_6 & C_2H_4	C_3H_8	C_3H_6	iC_4H_{10}	C_4H_{10}	C_4H_8	iC_5H_{12}	C_5H_{12}	C_6H_{14}+
1.	Dry Natural Gas	Absorber	86.56	8.67	3.92	.....	0.36	0.47	.....	0.2		
2.	Wet Natural Gas	Field	79.8	6.48	6.22	.....	1.35	2.33	.....	2.97		
3.	Wet Refinery Gas	Tanks, etc	46.78	16.51	18.8	.....	4.44	7.77	.....	2.76	1.51	1.43
4.	Wet Refinery Gas Raw	Gaso. tanks	7.17	15.21	34.72	.....	10.88	23.16	.....	4.29	3.02	1.55
5.	Wet Cracked Gas	Gas Separator 15 lb.	36.8	23.1	16.7	4.5	7.1		2.8	5.5		3.3
6.	Dry Cracked Gas	Absorber	44.4	40.65	2.95	12.0	.....	.....	.....	.....	.....	.....



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Elements of Applied Petroleum Production

By K. C. SCLATER

Article I

TYPES OF OIL WELLS

AN oil well when "brought in" and placed on production either flows naturally or has to be given some mechanical assistance in order to make it produce in sufficient quantity. Thus all oil wells fall into one of two classes—naturally flowing wells and wells produced by mechanical means. In each of these two classes there are wells of various types. This broad classification of oil wells is based on the production method; that is, the wells are grouped according to the method by which they are made to produce.

When oil and gas are produced from an oil pool, the formation or reservoir pressure falls and the natural forces causing the oil to flow into the well diminish. Hence during the life of the well the method of production has to be changed. It is seldom possible to produce an oil well that has been brought in as a naturally flowing producer by one method throughout its life.

A well will start off as a naturally flowing well and produce thus until the available supply of energy in the formation becomes insufficient to maintain efficient natural flow, then some mechanical method of production has to be employed. It may then be produced by gas-lift. Later, when it is no longer profitable to produce by gas-lift, another change is made. By this time the well will probably have reached the pumping stage, and thereafter will be produced by pumping. In other words, the well gradually changes its status from that of a naturally flowing well to that of a pumping well. This, as matter of fact, is the actual history of the average well that starts off as a naturally flowing producer—provided, however, no secondary method of recovery is employed.

By secondary methods of recovery we mean the injection of air, gas or water into the producing formation to increase the ultimate recovery of oil. Water flooding and repressuring with air or gas are examples of secondary recovery practices in use. It is not the purpose to discuss secondary recovery methods now; these will be taken up in a later article of this series. Their mention at this time is to draw attention to the fact that when a secondary method of recovery is employed it usually results in prolonging the life of the pool and may necessitate changes in the method of production at the well.

As oil moves through the reservoir rock toward the well, energy is used up. In most oil pools this energy comes from the pressure of natural gas dissolved in or associated with the oil in the formation. Part of the energy or force expelling the oil may come from hydrostatic pressure; that is, from water under pressure in the formation.

When the oil reaches the well there may be sufficient energy available in the natural gas to force the oil to the surface, in which case we have a naturally flowing oil well. A "gusher" is really a naturally flowing well, with an ample supply of natural energy.

If the available natural energy to flow the well is insufficient, auxiliary power has to be supplied from another source outside the well. Usually, however, there will be some energy present in the gas in the oil in the bottom of the hole that, although not sufficient to flow the well, will still be a valuable source of power. If properly used it will reduce the power required from sources outside the well. It is important, therefore, to know something about these natural sources of energy and how they exist underground in order to apply them most effectively to the production of oil.

To produce a well with a minimum expenditure of power per barrel of oil is the very foundation of good production practice so far as the field man is concerned. All improvements in production practice have as their object, directly or indirectly, a minimum expenditure of power per barrel of oil produced. This holds true whether the power necessary to produce oil is supplied from natural sources within the producing formation itself or from power equipment at the surface. This is the reason why, in recent years, so much stress has been laid on reduction of gas-oil ratio; for each cubic foot of gas produced with a barrel of oil represents an expenditure of so much energy or power. The gas-oil ratio is the ratio of the volume of gas produced to the unit quantity of oil produced, and, in the oil fields, is generally expressed in number of cubic feet per barrel.

The foregoing considerations explain why conditions in the reservoir or producing formation and the available supply of natural energy therein are so important[1] as natural factors influencing the method of production.

Naturally Flowing Wells

A naturally flowing well may be thought of as one flowing under its own power, that is, power from a virgin source—either gas pressure or water pressure, or both, in the reservoir—available within the well itself.

A flowing oil well, it should be noted, is not necessarily one that flows naturally. Wells may be caused to flow by applying artificial gas-lift methods or by building up a pressure in the reservoir or producing formation by the injection of air, gas, or water. Strictly speaking, a naturally flowing well is a gas-lift well if gas energy is the lifting medium, because any flowing well wherein gas pressure is the dominant source of energy lifting the oil to the surface is a gas-lift well and operates on gas-lift principles. This is the reason for using the term artificial gas-lift.

Natural gas under pressure is the most widespread source of natural energy in oil pools. How the gas is associated with the oil is important. It is found in close association with the oil either in solution or in the form of free gas. Under normal pressures the free gas may exist as a gas cap

in the producing formation or it may be disseminated in the oil. Under extremely high pressure, however, such as found in very deep fields—Big Lake and Kettleman Hills, for example—the association of the oil and gas and the state in which they exist are not so well known. The exact behavior of oil and gas under extremely high pressures is still imperfectly understood. We will have occasion to discuss this later.

Great quantities of gas produced with the oil in excess of that actually needed to bring the oil to the surface in the early life of a pool can be a source of great loss; for then the gas is usually under high pressure and a cubic foot of it will contain more energy than at lower pressures. Dissipation of pressure in the early life of the pool only leads to higher lifting costs when the wells get older.

When putting a naturally flowing well that has just been completed on production, a method that will result in producing the oil with the minimum volume of gas is given first consideration. By utilizing the available natural gas energy the flowing life of the well can be prolonged, the lifting costs reduced, and the ultimate recovery of oil increased. How to utilize[2] this natural energy is therefore to be stressed as one of the foremost problems confronting the operator who wishes to keep down his lifting costs over the entire life of the well.

Oil wells can be grouped under three heads according to the pressure and volume of gas available in the well, as follows:

1. Gas volume large and pressure high.
2. Gas volume small and pressure high.
3. Gas volume small and pressure low.

This grouping is convenient when considering the flowing possibilities of a well and the size of tubing, if any, to be installed.

Included in group 1 are wells that have gas of ample volume and pressure to enable them to produce through the casing by natural flow at almost any desired rate. The gas is sufficient in volume to maintain steady flow in the casing, and the pressure is great enough to overcome the highest pressure that could be exerted at the bottom of the well were the casing filled with oil. It may be possible to flow such a well at the desired rate through the casing with as low a gas factor as through the tubing. The question of whether or not to install tubing becomes a matter of choice.

Included in group 2 are wells that do not have gas in sufficient volume to maintain a steady flow of oil through the casing; but the gas pressure is great enough that the gas can continue to rise to the surface through the column of oil in the hole. By its action the gas keeps the column of oil in the hole alive or energized, at least enough to prevent "killing" the well. This is the type of well that flows by "heads," that is, it flows at intervals. In such wells it is necessary to install tubing for steady and efficient flow at the desired rate of production.

Included in group 3 are wells in which both the pressure and volume of the gas are insufficient to maintain flow in the casing. Even the pressure is so low that the hole will fill up with oil to the point that the gas cannot force its way through it to the surface. When this happens the well is said to have gone "dead." It may be possible to establish spasmodic flow, which is usually inefficient and is too irregular to be satisfactory. As in the case of wells in group 2, tubing must be installed for efficient flow at the desired rate of production.

The conditions found in wells under the three groups just outlined really are all phases in the flowing history of the majority of naturally flowing wells. Such wells when first placed on production will flow vigorously and continuously through the casing with a low gas-oil ratio, then later, as the pressure and volume of gas diminish, the flow will show signs of weakening and the gas-oil ratio will increase. After a while, the well begins to "head." If allowed to continue to flow thus, the intervals between "heads" increase until, finally, the well ceases to flow entirely.

As soon as a well flowing through the casing begins to head, it can usually be brought back to continuous flow again by running a string of tubing in the well. By selecting tubing of the proper size for the required daily rate of production the gas-oil ratio used can usually be reduced. This is the real purpose of using tubing. Effective use of the gas will, as already stated, result in prolonging the flowing life of the well and increase the ultimate recovery.

FLOWING THROUGH TUBING. It has now become general practice to tube naturally flowing wells as soon as they are brought in and before being placed on production. There are very good reasons for this. A lower gas-oil ratio for the desired rate of production is usually obtained. Regulations in effect in some states now require flowing wells in flush fields to be tubed. This is a conservation measure to limit the gas-oil ratio. With proration in effect, the daily rate of production is so low that continuous efficient flow is usually possible only through tubing. Better control of the well is possible when flowing through tubing. Advantage can be taken of the fluid level in the casing to increase the efficiency of flow.

Water in the bottom of the hole may also necessitate the use of tubing. Flexibility in the rate of flow is obtained by selecting tubing of the best size for the ranges of rates of flow desired. By means of chokes or flow beans, the use of which will not be taken up now, the rate of flow can be controlled from the surface and close control of the gas-oil ratio maintained.

FLOWING THROUGH CASING. Thus far we have been considering mostly naturally flowing wells where natural gas pressure is the source of energy. There are instances, however, where hydrostatic pressure is the dominant source of natural energy. A strong water drive is sometimes found in oil pools, particularly in limestone, where the natural gas pressure as a flowing agent may be negligible. The flowing characteristics of a naturally flowing well in a pool with a strong water drive are quite different from those of a well flowed by natural gas.

Since the source of energy is hydrostatic pressure, there will be little or no drop in reservoir pressure if the well is produced at such a rate that the water replaces the oil in the reservoir as fast as it is withdrawn. The limestone may be so permeable, allowing the oil and water to move quite freely in the producing formation, that a well will flow naturally through the casing at almost any desired rate and without any sacrifice in efficiency. In effect, what we really have is a flow similar to that of an artesian well. By installing an adjustable flow bean at the casing-head the well can be effectively controlled and any desired rate of flow obtained. In a well of this kind nothing would be gained by the use of tubing so far as flowing the well efficiently is concerned.

Wells Produced by Mechanical Means

Oil wells produced by mechanical means outnumber by far those produced by natural flow. It is estimated they comprise more than 90 per cent of the total number of wells producing oil. They include wells from the smallest stripper producing only a fraction of a barrel of oil a day to those produced by the most modern (artificial) gas-lift methods making several hundred barrels of oil daily.

Thousands of small wells are completed yearly in shallow

fields as pumping wells, most of which are immediately equipped for pumping by jack from central power plants. There are other wells completed that just fall short of being naturally flowing wells. New deep wells of this type generally can be produced efficiently by gas-lift through tubing. Then there is the large class of wells already producing that fall within the range between the stripper and the gas-lift wells. In this large class of wells we find those that are produced by regular pumping methods, by swabbing and bailing, and by special types of pumps.

SWABBING AND BAILING. Wells produced by swabbing and bailing methods are comparatively few. They are usually wells in which special conditions are encountered that preclude the use of other methods of production; for example, in moderately deep wells where large volumes of water are produced with the oil and where there is a lack of gas. Swabbing and bailing are carried on through the casing. As regular, efficient methods of production, however, they are rapidly being supplanted by more modern methods, hence are becoming relatively unimportant.

GAS LIFT. It is only within the last eight years that the real possibilities[3] of the gas-lift as a method of oil production have been recognized. Its development during this time has been rapid and today it is widely used. As a producing method it fills the gap between the naturally flowing period and the pumping period of a well.

Wells adapted to gas-lift are:

(1) Naturally flowing wells that are beginning to head and in which no further change in tubing size is feasible. As soon as a well begins to show signs of heading, accompanied by a sharp increase in gas-oil ratio, its period of natural flow is about at an end.

(2) In deep wells with reasonably high fluid levels where large quantities of water are produced with the oil. The formation of emulsions have to be guarded against.

(3) Those with crooked holes. The operation of reciprocating pumping equipment in such holes, especially if they are deep, is not always feasible, hence recourse is had to the gas-lift. Surveying of wells for straightness while drilling has solved the crooked hole problem. Few deep wells today are drilled crooked.

Gas-lift wells are equipped with either straight or tapered strings of tubing. In the larger strings of tubing, 2-in., 2½-in., and 3-in. are in common use. Small tapered strings of tubing using sizes from 1¾-in. to ⅜-in. diameter are being used to flow small wells. These small strings of tubing are generally used where the gas-lift is employed in conjunction with repressuring operations.

There are several gas-lift systems in use. Wells may be produced continuously or intermittently. When used intermittently the intermittent operation is usually automatic. The flow may be either through the tubing or between the tubing and the casing. The pressure of the compressed gas used depends on the depth from which the oil is lifted,[4] on the gravity of the oil, and on the quantity of formation gas accompanying in the oil. It is roughly about 10 lb. per 100 ft. of lift in a straight gas-lift system under average conditions.

There are many special adaptations of the gas-lift in use such as flow devices, intermittent flowing systems, air or gas displacement pumps, flow valves, kick-off valves, syphon lifts and plunger lifts.

RECIPROCATING OIL WELL PUMPS. The use of reciprocating oil well pumps actuated by sucker rods is the standard method of pumping. It is the most widely used method of producing a well. The method is adapted to both deep and shallow wells. Several wells are being pumped today from depths greater than 5000 feet.

In deep wells that have a low fluid level, little or no gas, and small daily production, this method of pumping is especially adaptable. Its use is most widespread in wells pumped by jack from a central power.

A recent development is the use of a pneumatic pumping head at the well for imparting the reciprocating motion to the sucker rods. Natural gas or air may be used in the pneumatic cylinder. This system of pumping is adaptable to the group pumping of wells from a central compressor plant.

Aside from its widespread use, producing a well by means of reciprocating oil well pumps and sucker rods is the oldest pumping method in use in the oilfields. We shall have occasion to discuss in some detail in later articles in this series this phase of pumping in its more modern aspects.

SPECIAL TYPES OF PUMPS. The constant and natural urge to meet the mechanical needs of producing wells has led to the development of special types of pumps. Most of these are of recent introduction and are thereby in limited use.

One, an electric-driven pump, is run in the well on casing or tubing and operates submerged in fluid at the desired point in the well. This pump is designed to operate with a low power consumption by having the motor and pump direct-connected in one unit. As the motor is at the point of power application, secondary power losses due to moving parts between the pump and motor are eliminated. Current is delivered to the motor by a cable.

There are two models of this pump; one a duplex reciprocating type and the other a centrifugal type pump for wells of small and large production, respectively. It is adaptable to all types of wells and in operation is not affected by well conditions, such as the presence or absence of gas, water, or low formation pressures.

Another pump of special design is hydraulically operated by oil pumped from the surface. This pump is of the reciprocating plunger type.

Most new pumps introduced are designed with the object of overcoming certain well conditions and adding more desirable features that will give greater flexibility to existing equipment.

●

QUESTIONS

1. What is a naturally flowing well? A gas-lift well?
2. In what respect does the method of producing a gas-lift well differ from that of a well flowing naturally?
3. What are the sources of natural energy in an oil pool causing wells to flow? Which is the more important?
4. Why is it desirable to maintain a low gas-oil ratio in flowing wells? In pumping wells?
5. Why is it usually desirable to produce a flowing well through tubing?

●

References:

[3]"Function of Natural Gas in the Production of Oil," by H. C. Miller—U.S.B.M. report in cooperation with the Division of Development and Production Engineering of the American Petroleum Institute, 1929.

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[3]"What Gas Lift Has Done," by F. W. Lake—Oil Bulletin, May, 1927, p. 543.

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Vocational Refinery Mathematics

OPERATORS in a modern refinery are responsible for the intelligent operation of many types of equipment and are required to be familiar with operating details that usually call for mathematical calculations of some sort. Many operators, because of limited training, or a desire to review the subject, frequently wish to have access to a short practical course on the subject. It is such a need that this series of concise articles on vocational refinery mathematics has been designed to meet. The author, P. Albert Washer, is a graduate engineer who has been engaged for several years in refinery work with the Humble Oil & Refining Company. In addition he has been teaching vocational courses for several years and is well qualified to present the subject in a manner that will be generally popular and profitable. The series consists of five articles covering the most practical phases of refinery mathematics.

ARTICLE I

By P. ALBERT WASHER
Refinery Engineer

THIS is the first of a series of articles on Vocational Refinery Mathematics. The series represents an attempt to outline and fulfill the request for a "Math" course of practical interest to refinery employees. It is written especially for the operators and those that have not had much training in technical work. With this in mind, little encroachment has been made in the field of Chemical Engineering, and only the more important practical phases of the subject are discussed.

The most prominent objects in any well-equipped refinery are unquestionably as follows:

1. Stills. (Coil furnaces).
2. Fractionating Equipment.
3. Cracking Equipment.
   Soakers, accumulators, etc.
4. Treating Equipment.
   Agitators, SO_2 Plant (Edeleanu), etc.
5. Condensing Equipment.
   Submerged Coil.
   Shell and Tube.
   Jet.
6. Pumps.
   Displacement.
   Impeller.
7. Tanks.
8. Lines.
9. Metering Devices.
10. Other Service Units.
    Power Houses, Boiler Houses, Cooling Towers, etc.

The items listed above will not be discussed in order of their importance in the refinery but rather in a sequence such that the mathematics involved in the intelligent operation of each item will be taken up in logical prerequisite order. Before considering the items enumerated in the foregoing list it is necessary that the average refinery worker have a fairly accurate knowledge of densities, gravities, viscosities and heat. Hence, definitions and explanations of these terms will first be reviewed.

Density. The term "density" is used to denote the mass of unit volume of a substance.

$$(1)\quad D = M/V.$$

For example, in the English system, the cubic foot is the unit of volume and the pound the unit of mass. Since one cu. ft. of water is found to weigh 62.4 lb. we say that in the English system the density of water is 62.4 lb. per cu. foot.

In the C.G.S. (Metric) system the cubic centimeter is taken as the unit of volume and the gram as the unit of mass. Unless expressly stated, density is now universally understood to mean density in C.G.S. units, that is, the mass in grams of one cubic centimeter.

Specific gravity is merely a density ratio and is the same in all systems.

$$(2)\quad \text{Sp. Gr. at } 60^\circ/60^\circ\text{F.} = \text{Density of oil at } 60^\circ\text{F.}/\text{Density of water at } 60^\circ\text{F.} = d/d'$$

which is equivalent to the following numerical relation:

Density of oil at 60°F. in lb./gal. = 8.34 × Sp. gr. of oil at 60°/60°F. Since d' is practically equal to one, the specific gravity and its density have almost the same numerical value (C.G.S. system).

The equi-spaced hydrometer scales in industrial use are arbitrary means of determining the relative weights of liquids. Degrees of gravity are equal divisions of a scale on these floating instruments. The formula on which is based the standard A.P.I. (American Petroleum Institute) scale is as follows:

$$(3)\quad \text{Sp. gr. } (60^\circ/60^\circ\text{F.}) = 141.5/131.5 + \text{deg. A.P.I.}$$

An easy way of remembering the formula, especially the respective position of the gravities, is to recall that the specific gravity of water is equal to one, hence, the number on the right side of the equality sign must equal one.

Thus: $1 = 141.5/(131.5 + X)$, that is,
X must equal 10, or $1 = 141.5/141.5$.

This is equivalent to the statement that the A.P.I. gravity is on the right side of the equality sign.

The Baumé formula is as follows:

$$(4)\quad \text{Sp. gr. } (60^\circ/60^\circ\text{F.}) = 140/130 + \text{deg. Bé.}$$

This scale is roughly one per cent lower than the A.P.I. scale.

Viscosity. Since fluid friction or viscosity must be reckoned with constantly in the refinery its study is of vital interest. Viscosity may be defined as the friction between adjacent layers of fluid having different velocities.

For liquids, viscosity increases with lower temperature and decreases with higher temperature. Recall pouring molasses in cold weather and "cranking" an automobile when the oil on the cylinders and bearings is cold.

For gases, the opposite relation holds true. That is, viscosity decreases with lower temperature and increases with higher temperature. It is quite probable that the viscosity of gases should not be attributed to molecular friction but rather to molecular motion. The viscosity of gases is much smaller than liquids and is by no means negligible. The slight viscosity of illuminating gas necessitates a certain pressure drop to force the required flow through dirty gas mains.

The coefficient of viscosity, n, is defined as the tangential (surface) force per unit area divided by the resulting velocity gradient (change in velocity per unit (cm.) change of depth v/d), or:

$$(5)\quad n = (\text{force/area})/\text{velocity gradient} = (F/A)/(v/d)$$

From the equation it is seen that the C.G.S. unit in which n is expressed, called the poise, is:

dyne sec./cm.^{2}, and a centipoise = 100 poises.

An example might clear up the equation. The coefficient of glycerine at 15 deg. cent. is 14.5; that is, if we had a layer of glycerine one cm. thick at 15 deg. cent. it would require a force of 14.5 dynes to move that surface (upper) at the rate of one cm. per sec. with respect to the lower surface (one cm. between surfaces).

Equation (5) may be put in the form:

$$(6)\quad n = P\pi r^4 t/8LV$$

in which V is the volume in cc. which a pressure of P (in dynes/cm.^{2}) forces through a capillary tube of length L (in

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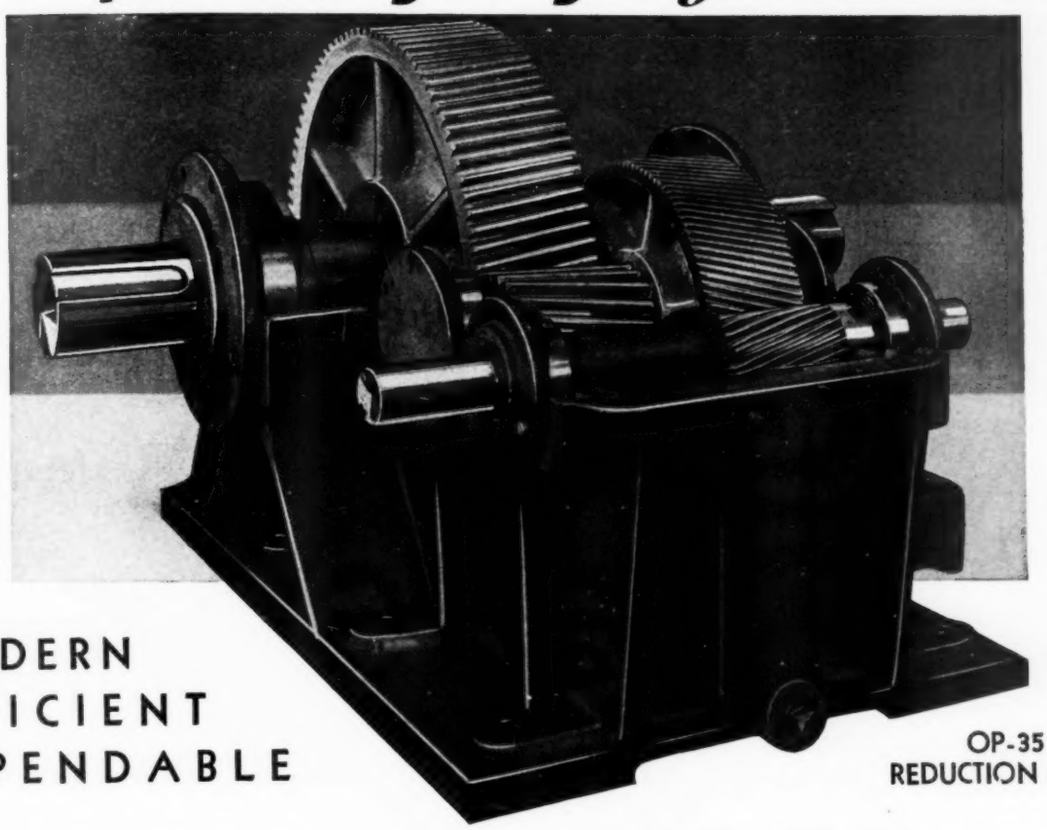

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cm.) and radius r (in cm.). This equation forms the basis of a simple and accurate laboratory method of determining n.

Absolute viscosity is obviously determined by time of flow through a capillary tube called a viscosimeter. Thus, a liquid with a viscosity of 90 Saybolt is one requiring 90 sec. to discharge a volume just sufficient to fill the chamber of the Saybolt viscosimeter through the orifice of that instrument under the changing though definite head that the instrument produces. The pressure drop through the tube itself is dependent upon the absolute viscosity of the liquid, but the entrance and exit losses are practically independent of the absolute viscosity, hence, the absolute viscosity is not directly proportional to the time of efflux.

The relation between the time of efflux (θ) in seconds and the viscosity varies for different makes of viscosimeters, and sometimes even for the various instruments supplied by a given manufacturer. Such instruments are calibrated against liquids of known viscosities. For the new standard Saybolt, the relation is as follows:

(7) $Z/S = .220\theta - (180/\theta)$

(not applicable to liquids of low viscosity) where, Z is the viscosity at any definite temperature relative to water at 68 deg. fahr., and S is the specific gravity at the temperature in question.

Thus, an oil of 100 Saybolt sec. and specific gravity of .9 at 150 deg. fahr. would have at this temperature a relative viscosity of: $20.2 \times 0.9 = 18.2$.

Relative viscosity may also be found by forming a ratio, i.e., the ratio of the absolute viscosity of the fluid to that of water at 68 deg. fahr., both viscosities being in the same units. Thus, a liquid having an absolute viscosity of 200 C.G.S. units at 150 deg. fahr. has a relative viscosity of: .200/.0100 (abs. vis. of water at 68 deg. fahr.) = 20.

To convert absolute viscosity from C.G.S. units to the English system simply multiply by:

(8) 0.0672

Thus, (0.0672) (.0100) = 0.000672 English units.

Kinematic viscosity is obtained by:

(9) Kin. vis. = abs. vis./sp. gr. (kin. vis. of water = .01).

(10) or, Kin. vis. = 0.00216 t — 1.8t where t = sec. Saybolt Universal.

Other viscosity formulae:

(11) $Z/S = 2.040 - (160/\theta)$ (Furol)

(12) Z/S = R.O. vis./157

where, Z is the relative vis. at t deg. fahr.
S is the specific gravity at t deg. fahr.
θ is the time of efflux, sec. at t.

As already stated, the viscosity of all liquids increases with temperature drop. This fact is of great importance in the pumping of oils. A certain crude oil at 120 deg. fahr. has only 1/16th of its viscosity at 60 deg. fahr. The pressure drop at 120 deg. fahr. will be only one-half the drop at 60 deg. fahrenheit. This phase is taken up in detail in the next article.

Heat. The subject of heat is rather complex in nature. Only a few terms necessary for understanding future problems are given.

The unit of heat most commonly used in the refinery is the B.t.u. or British thermal unit. It is the quantity of heat necessary to raise the temperature of one pound of water one degree fahrenheit.

The latent heat of vaporization is the number of B.t.u. required to change a pound of the substance from liquid to vapor state at a definite temperature and atmospheric pressure.

(13) $L = (1/d)(110.9 - .09t)$

in which L is the latent heat of vaporization in B.t.u./lb.; d = sp. gr. of liquid at 60°/60°F. and t = temp. in deg. fahrenheit.

Example—Given: Temp. 100 deg. fahr. sp. gr. .8251. Required: the latent heat.

Solution: $L = (1/.8251)\ (110.9 - \overline{.09 \times 100}) = 123.$

Specific Heat. The specific heat, s, of a substance is practically equal to the ratio of heat required to heat a given mass of a substance through a given range of temperature to the heat required to heat an equal mass of water through the same range. Thus, the specific heat of petroleum for all practical purposes is 0.50. This means that it would require 0.5 B.t.u. to heat one pound of oil one degree fahrenheit. In popular language it may be said that oil heats about twice as easily as water.

For figuring the specific heat of petroleum the equation used is:

(14) $c = 1/d\ (0.388 + .00045t)$

in which c is the specific heat in B.t.u./lb. per deg. fahr., d is the specific gravity at 60°/60°F. and t is the temperature in deg. fahrenheit.

Example—Determine the specific heat of a 30-deg. A.P.I. oil at 100 deg. fahrenheit.

Solution: $c = 1/.8762\ (0.388 + \overline{.00045 \times 100}) = 0.463.$

Specific Volume. No "Math" course is complete without dealing with expansion. For our purpose, we are more concerned with cubical expansion than linear expansion. To convey the significance of this subject the multipliers for the Tagliabue Manual were calculated from the following equations:

Temps. less than 60 deg. fahrenheit.

(15) 1.0000 — [(69—T) × coeff. expansion]

Temps. greater than 60 deg. fahrenheit.

(16) 1.0000 — [(T—60) × coeff. expansion]

The coefficients to be used for the different oils are given below:

Group	Coeff. of Exp. at 60 deg. fahr.	Corresponding deg. A.P.I.	Range of Group—A.P.I. at 60 deg. fahr.
1	0.0004	22	up to 34.9
2	0.0005	44	35 to 50.9
3	0.0006	58	51 to 63.9
4	0.0007	72	64 to 78.9
5	0.0008	86	79 to 88.9
6	0.00085	91	89 and higher

Examples—Determine the correction factor for a gasoline the A.P.I. of which is 48 deg. at 55 deg. fahrenheit.

Solution: 1 — [(60 — 55) .0005] = 1.0025.

Determine the correction factor for a gasoline the A.P.I. of which is 38 deg. at 65 deg. fahrenheit.

Solution: 1 —[(65 — 60) .0005] = .9975.

Absolute Temperature. The absolute temperature is obtained in centigrade degrees by adding 273 to the centigrade temperature, and in fahrenheit degrees by adding 460 to the fahrenheit temperature. The centigrade absolute scale is often called deg. K (Kelvin) while the fahrenheit absolute scale is called deg. R (Rankine).

Thus, 68°F. = 528° Rankine (68 + 460 = 528)
255°C = 528° Kelvin (255 + 273 = 528)

EASY METHOD OF TEMPERATURE CONVERSION

Fahrenheit to Centigrade:

1. Add 40 to given temperature.
2. Take 5/9ths of this result.
3. Subtract 40.

Centigrade to Fahrenheit:

1. Add 40 to given temperature.
2. Take 9/5ths of this result.
3. Subtract 40.

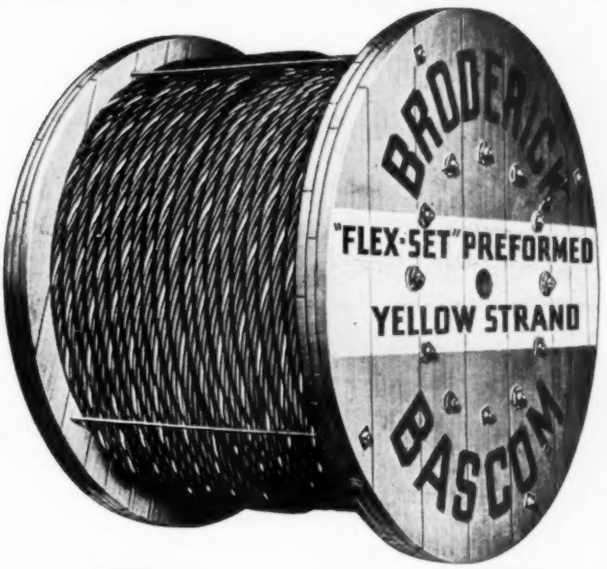
Example:

Given: 68 deg. fahr. Convert to centigrade degrees.

Solution:

1. 40 + 68 = 108
2. 5/9(108) = 60
3. 60 — 40 = 20 deg. centigrade.

Quick Wire Line Deliveries by The Continental Supply Co.



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Progress Being Made i

FORMATIONS abound in the fields of the Gulf Coast that exhibit most pronounced caving tendencies when penetrated, creating drilling difficulties that only the greatest skill, experience, and perseverance can successfully overcome. The formations that cause trouble are generally large bodies of shale several hundred feet in thickness, the physical and chemical make-up of which, aided probably by the dip of the strata, is responsible for the inordinate caving tendencies that bring about what is commonly known as a "heaving-shale" condition.

A satisfactory solution to this heaving-shale difficulty has challenged the efforts of operators in the Gulf Coast as few drilling problems have. It has cost them hundreds of thousands of dollars and the loss of many a hole. Mud control, the exercise of vigilance in all the mechanical operations of drilling, and recourse to special bits and equipment have been called into play in coping with this formidable problem. Operators have learned that the great thicknesses of shale usually encountered call for the exercise of the utmost care in every detail of drilling if trouble is to be avoided.

Incipient trouble leading to heaving-shale conditions are being given close study

Despite the efforts put forth and the advanced practices employed, however, the results obtained are frequently only partially successful in preventing or overcoming a heaving-shale condition; nevertheless, substantial progress is being made. Systematic methods and the technique of mud control are rapidly being developed, whereby failures are becoming fewer, even though drilling depths are becoming increasingly greater. During the progress of drilling the properties of the mud are maintained, and adjusted as often as is necessary to meet the specific drilling conditions. So important has mud control become in Gulf Coast drilling operations that several companies now have one or more trained men who devote their entire time to it.

Developments and improvements are constantly being made also in tools and other equipment, including methods of handling these while drilling through heaving shale. A complete and satisfactory solution to the problem lies in proper mud control, suitable equipment and alert handling of all the mechanical operations of drilling.

Methods of preventing or overcoming a heaving-shale condition can be considered from two angles, both of which are equally important; one is that of mud control and involves principally a consideration of chemical treatment and conditioning of mud while drilling; the other is that of mechanical control of drilling operations, which involves the design, the type, and the mechanical operation of the drilling equipment.

Investigations of drilling difficulties by competent observers lead to the belief that the incipient trouble leading to a heaving-shale condition is the infiltration of water to the formations through the walls of the hole. The most troublesome formations are usually composed of layers of compacted, indurated shale, with intercalations of softer shale. The latter have a great affinity for water, which when taken up, results eventually in their being leached out. This leaching process leads to caving on a progressive scale that subsequently reaches to the mass of shale in and adjacent to the hole throughout its entire thickness and causes it to heave. The presence of bentonite in the shale, if not the real root of the trouble, is believed in many cases to aggravate it considerably.

Sometimes the hard layers of shale are held together by some material such as salt, which dissolves readily in water, and which when removed leads to serious caving and subsequent heaving. Every time the drill pipe is pulled, the hole fills up several hundred feet. It is as a result of these sad experiences that the efficacy of drilling muds as an aid in preventing and overcoming the difficulty has become a matter of great moment to operators and has led to the launching of investigations in the field covering all angles of the problem.

Mud fluid has certain well-defined functions in drilling, chief among which are:

(1) Carrying the drill cuttings from the hole;
(2) Plastering the wall to prevent caving or sloughing and to seal the formations penetrated against the infiltration of water or mud;
(3) Providing hydrostatic pressure to counteract high-pressures in formations and confine gas, oil or water in place during drilling;
(4) Preventing settling of cuttings when circulation is interrupted;
(5) Facilitating the floating in and cementing of long strings of casing;
(6) Acting as a lubricant for drill pipe and bit; and,
(7) Dissipating heat generated by bit and drill pipe in drilling.

To perform these functions efficiently drilling mud must have certain desirable properties, the most important of which are: (1) Weight or specific gravity, (2) Viscosity, and (3) Gelation or Colloidality.

The importance of the respective functions of drilling mud are not the same for every well but will vary according to the conditions in the hole; likewise, the importance of the respective properties will vary. Rarely are the natural drilling muds obtained from the formations penetrated in drilling satisfactory. They are usually lacking in one or more of the necessary properties that good drilling mud should possess. Recourse is therefore had to treatment by chemicals or mud-making materials, or both, to impart the desired properties to suit the drilling conditions. For example, weight is an important property while drilling through high-pressure formations, especially if these are shallow. In general, the greater the depth the closer the control of the mud weight that is necessary; if too great it may do serious damage to productive horizons and if too small it increases the hazard of a blow-out. Weight is also an effective aid in preventing caving and maintaining the wall of the hole where the formations are unconsolidated.

When shales that have a tendency to heave are exposed in open hole, viscosity and gelation become of greatest importance. Weight and consistency are frequently used synonymously and thus become a source of confusion to men in the

« By K. C. SCLATER »

Combating Heaving Shale

field. A thick, sluggish mud is referred to as a heavy mud, when, as a matter of fact, the consistency of mud has no relation to its weight. Of two muds of equal consistency one might be almost twice as heavy as the other; for example, a light Aquagel mud may have the same consistency as a heavy Baroid or Colox mud.

More obscure is the relation between viscosity and consistency. Viscosity is a measure of internal fluid friction; but consistency, which is a measure of fluidity, is closely related to the viscosity, and really depends upon the plasticity of the solid material in the mud fluid, the dispersion, and the liquid state. In the use of the term plasticity also, it is well to bear in mind whether reference is made to liquid mud or to solid mud. It is necessary to distinguish between them.

Plastering of the wall of the hole is aided by the rotation of the drill pipe as the filter cake is built up. The filter cake, although it is used as a seal and is an effective aid against infiltration of water or mud into the formations, plays no great part in overcoming high pressure in the formation. Weight of the mud (or a pressure on the circulation system) is important in counteracting high formation pressure; without either, the mud sheath or filter cake has little value. The reason for this is that the filter cake or mud sheath formed on the wall of the hole, although it is, or should be, impermeable to fluids even under high pressure, can be easily removed. A slightly higher pressure in the formation of only a few pounds over the pressure of the fluid in the hole is sufficient to remove the filter cake. If the mud is too heavy, that is, the spacific gravity is too great, it will interfere with the settling of the cuttings. The solids of moderate or lightweight such as sand, pyrites, shale particles and the like, will not settle out, resulting in their being carried back into the hole and being recirculated. The presence of these in the circulation system will eventually cause trouble and excessive wear in the circulating equipment.

Mud control and the mechanical aspects of drilling have become important factors

Gelation or colloidality is the property depended upon to hold cuttings in suspension when circulation is interrupted. An insufficiency of this property should circulation be stopped may cause the cuttings to settle and result in freezing the drill pipe in the hole.

Viscosity is the property that governs the effective capacity of the mud in carrying the cuttings up and out of the hole. At the same time it should not impede the settling of the mud in the ditch and sump at the surface. It has to be so maintained that the cuttings drop out at a rate commensurate with the speed of pumping, between the casinghead discharge at the surface and the slush pump suction. Another factor assisting viscosity in this operation is the velocity of the mud fluid up the hole. This is governed, of course, by the speed of pumping. The carrying capacity of mud fluid varies directly as some power of the velocity of flow, depending on the properties of the mud. It also depends on the size and the density of the particles of the cuttings. As this carrying operation of the cuttings takes place between the bits and the surface outside the drill pipe (assuming the orthodox method of circulating down inside and up outside the drill pipe is used), the cross-sectional area of the annular space outside the drill pipe is the factor that determines the average velocity of flow of the mud from the bit to the surface for different rates of circulation. The velocity of mud fluid will be greatest at tight places in the hole and least in cavities. By means of a proper mud, however, combined with care on the part of the driller, a fairly uniform cross-sectional area can be maintained on the annular space behind the drill pipe.

Obviously, if the velocity of the mud be too great it may wash off the filter cake from the wall of the hole. If a heaving-shale condition develops the size of this annular space may become so small as to restrict or shut off circulation entirely. The annular space outside the drill pipe may be so small at places that only by maintaining a very slow rate of circulation can the removal of the filter cake be avoided. Once this is removed the tendency of the shale to cave may be greatly aggravated.

There are other complications that enter when this condition develops; for example, the matter of the viscosity of the mud fluid. If the viscosity is insufficient it may lead to settling of the cuttings in the hole to cause freezing of the drill pipe, or to hydraulicking of the hole, the latter resulting in further caving and sloughing. If, on the other hand, the viscosity is too great, other hazards are set up. In the hole, it may lead to excessive building up of the walls and to swabbing of the hole when the drill pipe is pulled; at the surface, the settling of the cuttings will be seriously retarded. It is when such conditions arise that the skillful treatment of mud by chemicals and mud materials begin to have a powerful influence, and dexterity on the part of the driller in handling the rig becomes imperative. The problem involved is both chemical and mechanical in character.

When the hole is deep the required velocity cannot always be developed sufficiently for the positive removal of cuttings, in which case the viscosity of the mud is adjusted to meet the conditions. In a case of this kind it becomes necessary to condition the mud, and to give it the necessary gelation properties that will prevent settling of the cuttings in the hole. Both the viscosity and gelation can be increased without adding to the weight of the mud. The heavier the mud the greater the pump pressure required. While the carrying power of heavy mud is very great, the excessive pump pressures required may limit its use for this purpose.

The method pursued in overcoming a heaving-shale condition is determined largely by the local conditions. The mechanical aspects of the method are every whit as important as that of mud conditioning.

Attempts to drill and to set casing through heaving-shale are fraught with mechanical difficulties. The holding of high-pressures while drilling has been resorted to in the past with indifferent success. Attempts to freeze the heaving-shale to hold it in the solid state, and the use of various kinds of gases for the same purpose have also been tried, but have not given very promising results.

Heaving shale has been successfully drilled through by

means of the Reed Wire Line bit. This is a drilling-coring bit with collapsible blades, and, as its name implies, is run on a wire line. In one particular well in Goliad County, South Texas, a special Reed Wire Line bit with collapsible blades, designed to drill a 13¾-in. hole, was run on special 8⅝-in. external upset casing. The bit was screwed on and welded to the lower end of the 8⅝-in. string of casing. In addition, the six joints above the bit head were securely screwed together and welded. The interesting mechanical aspect of this job was the use of the 8⅝-in. external upset casing first as a drill stem, after which it was then set and cemented as casing when the casing seat had been reached.

In this well about 600 ft. of shale (heaving type) was encountered between 4200 and 5000 ft. The special collapsible bit was run on a wire line in the 8⅝-in. casing at 4200 ft. One week and four hours later the casing seat was reached at 5144 ft., at which point the casing was set and cemented. The blade-carrier body assembly and blades of the bit were successfully recovered up through the drill stem (8⅝-in. Spang Chalfant casing) before cementing. Throughout the course of drilling with the wire line bit a pressure of 600 lb. was maintained at the pumps with 10.2-lb. mud in the circulating system. No back pressure was held against the formation. From 2000 to 10,000 lb. of new mud, composed of El Paso Clay and Buroni, was added daily. The special bit head used so successfully on this well had a large bore so that when the bit head was cemented in as a casing shoe, drilling of the cement and the formations below the casing seat was done through the bit head with the next size smaller bits and drill stem.

Much trouble and expense will be saved if, instead of continuing to fight a heaving shale with inadequate mud facilities and equipment, proper mechanical means are employed as soon as the heaving shale is encountered. In the case of the special wire line bit described, a heaving-shale condition, if allowed to go too far, gives rise to a condition that hinders successful operation of the bit. This generally holds true no matter what facilities or equipment is used subsequently to combat the trouble.

Swabbing action resulting from pulling of the drill pipe is one of the most prolific sources of trouble where caving or a heaving-shale condition is encountered. Regardless of the precautions taken and the care exercised it seems sometimes as if this swabbing action can not be prevented. Where trouble from this source is acute the use of flush-joint drill pipe offers a means of overcoming the difficulty, and is another of the mechanical methods now claiming the attention of Gulf Coast operators.

A complete and satisfactory solution to the problem of preventing and overcoming heaving-shale conditions seems to be in proper mud control, adequate mechanical equipment and dexterity on the part of the driller and his crew.

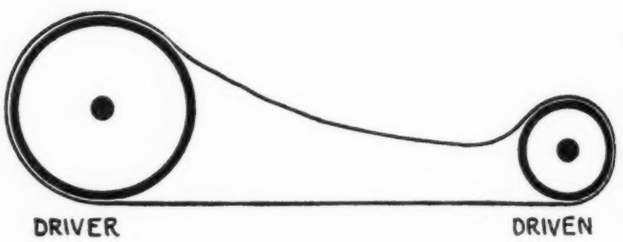
Determination of Belt Slip

By W. F. SCHAPHORST
Mechanical Engineer

HERE is a simple and accurate method for determining belt slip when conditions are such that the driven pulley can be operated for a while at full speed but "without load."

The method is based on the logical assumption that when no power is being transmitted through the belt there is no belt slip. The driven pulley, then, will rotate as many times per minute as it is possible for it to rotate. When the belt is transmitting full load, however, there is bound to be some loss due to belt creep and possibly some slip, so that the driven pulley will not rotate so rapidly as when "unloaded." The difference in r.p.m. of the driven pulley, then, divided by the r.p.m. it made "unloaded" multiplied by 100, gives the percentage of slip.

For example, in the accompanying sketch is shown a typical drive. Assume that the driver pulley runs 200 r.p.m.



Typical belt drive

while the driven pulley runs 340 r.p.m. in an unloaded state. But when the belt carries full load, the driven pulley makes only 320 r.p.m. What is the percentage of slip?

Using the above rule we find the answer to be 5.9 per cent slip.

Belt slip is always an important item because each per cent of slip virtually means a loss of one per cent of the yearly fuel bill. If the above slip can be reduced to two per cent (and it usually can) the yearly saving on fuel expenditure would be about four per cent.

Advantages of Air-Filters for Large Stationary Gas Engines

By F. L. KALLAM
Industrial Engineers, Inc., Los Angeles

THE results of a series of tests made by the United States War Department in 1924 definitely established the value of air-filters installed on automobile engines. Their method was to mount two new engines on test blocks, and connect the carburetor air-intakes with a specially prepared "dust box." The hose leading from the box to one intake was left unprotected, and the other was provided with a suitable filter. It was found that at the end of the equivalent of 3,000 miles, the unprotected motor was completely worn out, whereas the protected motor was in first class condition. Furthermore, the unprotected motor showed a 40 per cent higher oil consumption.

Air-Filters Becoming More Universally Used. Although the automotive industry has unanimously adopted this protective device, its use on stationary internal combustion engines has been more or less limited to installations located in desert or beach districts. Such failure to employ air-filters may largely be attributed to a lack of appreciation that "clean air", as compared with even "reasonably clean air", is a worthwhile investment when considered from the standpoint of engine life and maintenance expense. The magnitude of such savings are probably not recognized because of the difficulty in obtaining such information from actual operating units, a fact which also accounts for meagerness in the literature of the subject. Then, too, the first cost of filters for engines of large horsepower would have a tendency to stand in the way of their purchase unless a careful investigation of the entire situation is made.

Reduced cylinder wear and lube oil consumption are benefits derived

Function of Air-Filters. The function of these air-filters is to free the air delivered to the engine cylinders of silica and other abrasive material that will cause cylinder wear and add to the gritty carbon accumulation on the cylinder and piston heads. In this connection, however, it is necessary to keep in mind that wear of this nature may be negligible as compared to that caused by excessive carbon deposit or insufficient lubrication. For this reason it is felt that satisfactory lubrication and combustion of fuel must first be achieved before the advantage of an air-filter can be realized, and the remaining discussion is predicated on this assumption.

Air-Filter Efficiency. When speaking of "efficiency of air filters" in the present sense, it is necessary to understand that the term means a measure of their effect in prolonging the life, and reducing the maintenance expense on gas engines rather than a measure of the proportion of dust in air that they are able to remove. This point is brought out because the filters now available are capable of removing over 99 per cent of the dust from the air that passes through them.

Types of Air-Filters. The air-filters suitable for use with gas engines may be grouped into two general classes: the dry type, and the wet type.

In the first type, the intake air is caused to pass through one or more pieces of felt cloth, usually made in the form of a bag, and supported on a wire framework. The dust settles upon the outside of the bag, from which it is brushed or blown-off at suitable intervals.

The second type of filter consists of a box-like framework, or cell, filled with oil-soaked steel wool or similar material, through which the dust-laden air passes. The dust is deposited on the oil film as the air goes into the cylinder. When the oil becomes saturated with dust, the filter is washed and then dipped in fresh oil.

Air-Filter Requirements. The prime requisite of any type of filter is that it remove practically all the dust from the air passed through it. Second in importance is the requirement of a very low resistance to the passage of air, not only when the cells are freshly charged, but during the entire run, up to the time of the next cleaning. A third consideration is the ability of the filter successfully to withstand the shock of a severe backfire. Some manufacturers of felt bag filters maintain, however, that an occasional backfire is not unwelcome, as it blows the dust off the surface of the bags. Finally, the item of low maintenance cost is to be considered. Cells, or sections, should be of light weight, and readily accessible, so that they may be cleaned easily. The periods between cleanings should be as long as possible.

Determining Cylinder Wear. The determination of the conditions under which an air-filter will be an economical investment involves setting up a relation between dust concentration in air, and cylinder wear. Before so doing, it becomes necessary to determine the ratio of total cylinder wear to wear chargeable to abrasives introduced into the cylinder via the air intake. Unfortunately, it cannot be assumed that this ratio is always proportional to the percentage of silica present in the carbon deposit, and therefore a carbon analysis is of little value for this purpose.

It is felt that the only satisfactory method of isolating the wear due to dust only, is to install an air-filter on one cylinder of a twin engine provided with new power pistons, rings and liners. During the operation of this unit, the dust content of the surrounding atmosphere should be measured at suitable intervals. Upon the completion of a test run of say 12 months, the two cylinders can be measured, and a fair idea of wear chargeable to dust obtained. Loads, lubrication, cooling, and other operating conditions should be duplicated as nearly as possible where such tests are run on separate engine units, so

that the only variables encountered will be the concentration of dust in the air and the wear due solely to abrasives entering with the air.

For determining the dust content of air, a portable measuring device can be used, consisting of a fan-type blower of known capacity connected to a special filter of the felt bag type. The removable bag can be weighed before and after a test run, so that the percentage of dust in the air can readily be calculated. Unfortunately, such test methods have not been established long enough to provide sufficient data to be able to say for a given locality, "An air-filter is needed here," or, "An air-filter is not needed here."

Benefits Derived from the Use of Air-Filters. In March, 1932, a dry felt bag type of filter was installed on the air intake of a 160-hp., type 80, Cooper-Bessemer engine. This unit, and the adjoining one, were overhauled at this time, and micrometer measurements of the power cylinders recorded. Both units were run continuously with identical loads, lubrication, and other operating conditions until June. At this time both engines were examined, and the dust collected on the filter weighed. It was found that 183 grains of dust were intercepted, but apparently the period of operation was too short to reveal any improvement in cylinder wear. There was a marked reduction of dust deposit in the mixing valve of the engine protected by the air-filter as compared to that of the unprotected engine. The pistons and heads were replaced without being cleaned, and the test continued, but the later results are not available.

During the past four years, however, another compression station has had an interesting experience with piston ring wear in two 160-hp. units. These units are identical and are of the 4-cycle design with 18-in. by 20-in. cylinders, operating at 190 r.p.m. At certain times of the year this plant is exposed to severe dust storms.

These two engines were operated from 1927 to 1930 without air-filters, and at the end of the first year of operation, a fairly normal liner wear of 10/1000 of an inch was recorded. In the second year, however, after five months of running, it became necessary to replace the piston rings. The periods between ring replacements decreased steadily thereafter, until the end of 1930, when the average life of piston rings dropped to between 45 and 60 days.

In November of 1930, the power pistons and liners in both engines were replaced, and the air-filters were installed. After operating 3500 hours it was not necessary to clean the mixing valves, and the cylinder liner wear amounted to 3/1000 of an inch. The piston rings were also in excellent condition, and apparently were good for many more months of service.

From a consideration of dust measurements during these periods it is of interest to note that where the dust entering the engine amounted to 46 grains per cylinder per month, the piston rings lasted only 60 days, and where the dust amounted to 40 grains per cylinder per month, the rings lasted approximately one year. While the data are not conclusive, and should be supplemented by a number of additional tests before reaching a final conclusion, they are indicative of what can be accomplished in engine upkeep by the use of air-filters.

One manufacturer of air-filters claims to have installed his filters on ten large gas engines in 1925 at a cost of $964. These engines had been operated for six years without filters, so comparative operating costs were available. The net yearly saving that resulted from the use of these filters, after deducting interest on the investment, depreciation, and maintenance costs, was $631, or a return of 65.5 per cent on the investment. Direct savings consisted of 25 per cent reduction in lubricating oil consumption, 34 per cent reduction in valve replacement and maintenance, and decreased wear on cylinders and pistons. On the basis of this installation the operating company equipped their nine other compression stations with air-filters.

A second case of record is that of a railroad, which installed filters at a cost of $312 on two air compressors that had been in service for a period of four years. The net yearly savings in this instance, after deducting interest, depreciation, and maintenance costs, was $195.86, or a return of 62.8 per cent on the investment. Direct savings were as follows: 200 per cent increase in life of valves, 90 per cent reduction in cost of valve cleaning, and 33 per cent reduction in lubricating oil consumption. In addition to these savings, wear on cylinders, pistons, and piston rings were reduced, and in all probability these unrecorded savings actually amounted in dollars and cents to the savings on which records were kept.

Further evidence of the effectiveness of air-filters is available from the records of a Diesel-engined power plant. Here the units equipped with filters showed only 13 per cent of the cylidner wear that the unprotected units showed.

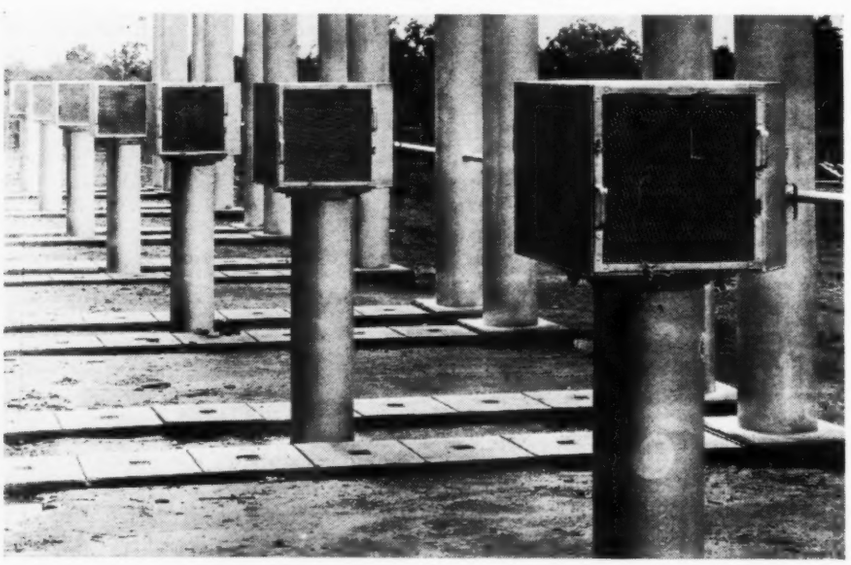
Improvement in Air-Filters. Certain improvements can be made in air-filters for this type of service that include subjecting the atmospheric air to a finely divided spray or mist of cold water before introducing it into the suction manifold. The beneficial results of this washing action are three-fold, namely:

1. The air is scrubbed clean of all abrasive material.
2. The temperature of the cleaned air is reduced.
3. The cleaned air is saturated with water vapor.

Obviously all three of these results are highly desirable in engine operation.

Benefits from Cool Air. Cooling of the combustion air increases the volumetric efficiency of the engine and permits increased horsepower output. This is especially advantageous in engines using gaseous fuels (natural or artificial) and in machines operating on the Diesel principle. This point is well brought out by

Air-filters protecting seven gas engines



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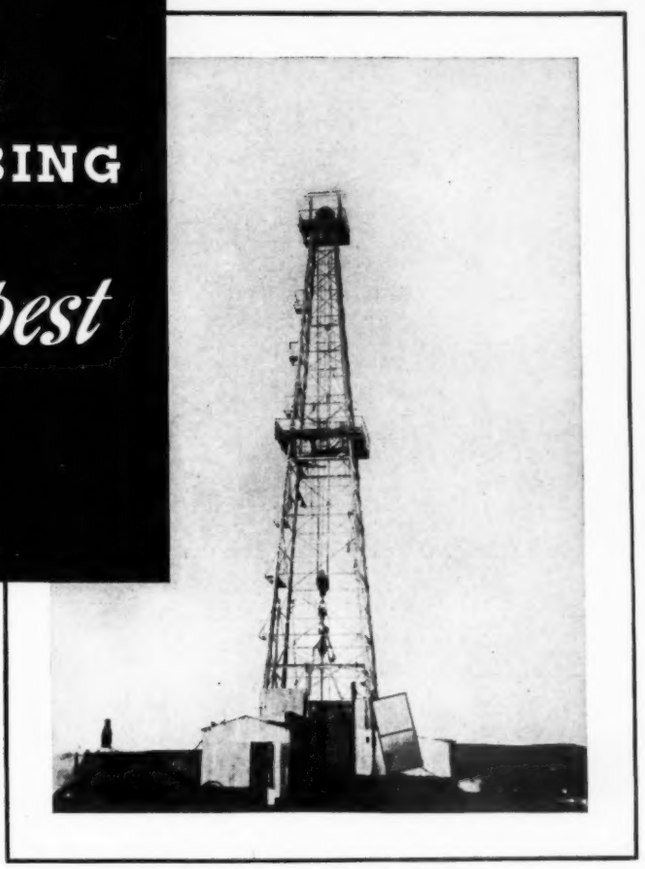

THE North Kettleman Oil and Gas Company drilled the Lillis & Welsh No. 1 well at North Dome in Kettleman Hills, Calif., to 10,946 feet—the world's deepest well.

A string of Republic Electric Weld Upset Tubing 8,300 feet long was used to swab the well. When the tubing was pulled the collars were found to be as tight as when the string was made up, in spite of the exceptional depth and the extraordinarily high stresses imposed. Again—this well was swabbed to a depth of 7,500 feet with only two sets of rubbers—and the second set was still in serviceable condition at the completion of the work. Previously, with other tubing in the same well, seven sets of rubbers had been required to do the same work.

All of which proves several things about Republic Electric Weld Tubing—that the steel and the electric weld are 100% and can take punishment—that the roundness, uniformity of diameter and smooth inside surface are positive factors making for maximum economy in use.

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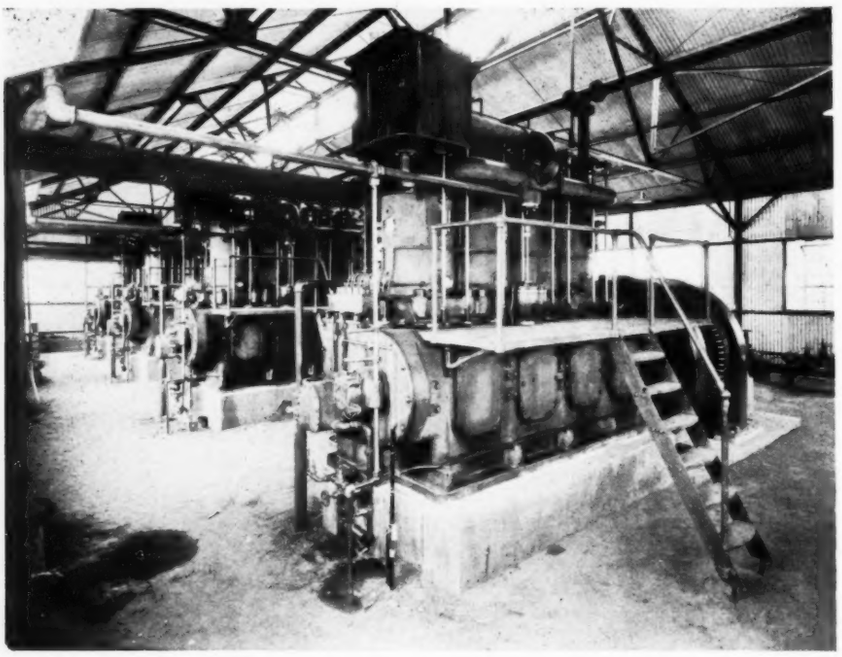


Interior of an air lift plant in Oklahoma, showing position of air-filters

test results obtained from a natural gas engine, which are as follows:

Influence of Temperature of the Gas-Air Charge on the Maximum Load of a Gas Engine

Charge Temperature Deg. Fahr.	Load Capacity Per Cent
150	100
200	92.5
250	86
300	80

For those engines where the air must be previously heated in order to vaporize the fuel charge, reduction of air temperature would be a detriment rather than a benefit. In such cases, however, warm spray water can be utilized in the filter without sacrificing any of the other merits of the apparatus.

Benefits from Saturated Air. Everyone has experienced the improved operation of an automobile engine when driving in foggy weather. It is especially noticeable when fog banks are encountered at intermittent intervals. The moisture content of the air has in a degree the same effect as the addition of tetra-ethyl lead to gasoline used in motor car service. It decreases the rate of flame propagation and thereby inhibits the tendency to knock with the result that engine performance is smoother.

This effect of humidity on knock rating has been scientifically substantiated recently in Germany, where numerous gasolines were tested at relative humidities varying from 30 per cent to 90 per cent. It was found that up to 45 per cent humidity little change occurred in the octane number, but above this large differences were found. For example, in the case of a poor gasoline, which tested 56 octane at 40 per cent humidity, at 70 per cent humidity the rating was raised to 64 octane. For ordinary commercial gasoline, which tested 68 octane at 50 per cent humidity, the octane number became 76 with 82 per cent humidity.

In certain marine fields it has long been the custom to inject water into the intake manifold when the engine was operating under full-load conditions in order to reduce the tendency to knock. Where this expedient is practiced, it would be a simple matter to arrange for pre-cooling and washing the air so as to gain continuous improved performance.

Advantages of Continuous Wet Wash Principle. By employing the continuous wet wash principle to air-filters, several advantages are gained. These are as follows:

1. Lower pressure drop to air passage with no increase during operating period.
2. No maintenance expense for cleaning.
3. Most efficient type of dust removal.
4. Provides air saturated with water vapor resulting in smoother engine operation.
5. Provides control of air temperature, permitting increased horsepower output.
6. Reduces tendency of engines to overheat at heavy loads.

The principle thus permits of improved engine performance in addition to the fundamental purpose of supplying clean air to the cylinders.

Kendall Winship Claimed by Death

Kendall Winship, 42 years old, one of the Mid-Continent area's younger oil executives, died suddenly from heart disease on November 8 at a Tulsa, Okla., hospital after an illness of only five days. He was vice-president, manager and secretary of both the Gypsy Oil Company and the Gulf Pipe Line Company of Oklahoma.

Mr. Winship attended the recent Chicago convention of the American Petroleum Institute and returned to Tulsa evidently in good health. He attended a meeting of the Oklahoma production code committee on November 6 and had a light heart attack there, but it soon passed off and he took part in the discussion before the assembly of oil leaders.

Winship came to the Mid-Continent oil country after serving with the American forces in France during the World War and worked for the National Supply Company. When the old Roxana (now Shell) Petroleum Corporation and the Marland (now Continental) Oil Company formed the Comar Oil Company, he went to work for them and soon became production foreman. Later he was with the Roxana in its Creek-Tulsa division. In 1924 he joined the Mellon organization and after service in Texas and at the home office in Pittsburgh, Pa., he was sent to Colombia and Venezuela, where the Gulf companies had obtained extensive properties. He remained there four years. In 1930 he came to Tulsa and was made a vice-president and assistant to the manager of the Gypsy-Gulf. When Mr. Henry McGraw died in May, 1931, Winship became acting manager and subsequently manager.

Mr. Winship, his friends say, had suffered slight heart attacks for some time, but being of a retiring nature, had never complained. The news of his death came as a distinct shock, as he had been reported as resting easily even after having been taken to the hospital.

Cutting Up Old Pipe Lines

By
N. E. WAGNER
Welding Engineer

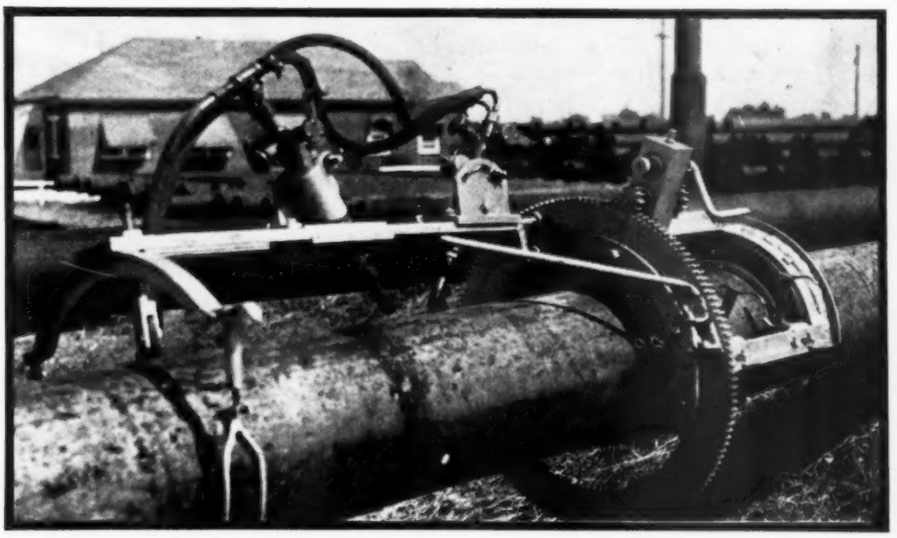
FOR the past 12 years thousands of miles of welded lines of various sizes have been laid throughout the United States and in many foreign countries for transporting gas and crude oil. Since the laying of these lines, various factors have frequently influenced companies to make changes of lines from one locality to another; some of these changes required only cutting up the pipe and trucking it from one job to another, but others necessitated cutting up and shipping from one state to another. As it is likely that the future will witness additional changes of this kind, such work will therefore become more important.

A major project involving one of these changes was recently completed. Some three years ago, the Prairie Pipe Line Company laid a 12-in. line, ripplewelded, from Oklahoma City to Coffeyville, Kansas, approximately 150 miles long. When the Sinclair-Prairie Pipe Line Company acquired the Prairie properties it had no use for this line, consequently, it was decided to take it up and relay it from Teague, Texas, to Huffman, Texas, a distance of 140 miles. Plans were made to take the line up by cutting with the oxy-acetylene torch; in relaying it, 70 miles of the line was to be Lindewelded and 70 miles electric-welded by the Lincoln Fleetweld method. Meador & Whittaker, contractors at Burkburnett, Texas, were awarded the north 70 miles from Teague to Anderson, Texas, which portion was welded by the Lincoln Fleetweld method, H. A. Price of Bartlesville, Okla., being given the sub-contract for lining up and welding. The 70 miles on the south half of the line was awarded to Truman Smith Construction Company of El Dorado, Kansas, and was Lindewelded.

The only preliminary work done on the line before raising it for cutting was to displace all oil with water. It was deemed advisable to run a scraper or go-devil ahead of the water so as thoroughly to clean the line of basic sediment or paraffin. After the line was raised from the ditch and placed on skids at regular points, it was cut at all creek crossings or low places so as to allow it to drain, thus enabling the cutting machine to operate without delays due to water or oil pockets. By using two machines, 75 miles of 12-in. line was cut up in 50 working days; from 100 to 140 double-cuts were made by each machine per day. The type of machine used was designed to cut out old welds with spacing of torches from 2 to 2½ in. at cutting jets. Almost any desired bevel can be obtained by adjusting the torch holders to the degree range marked on the machine. When cutting up lines the machine was operated by operator and helper; the helper carrying the hinged gear with cutting arm and torches attached, the operator moving the saddle to be placed at next cut. In operation, the saddle is placed on the line, the gear dropped into place, the saddle hooked up with flat chains and spring fasteners so as to hold it in place, and the gear wheel is then hooked together with an eye-bolt and wing nut. At the end of the arm is a post roller and basket roller to help support the arm while making double cuts. After the cut is three-fourths completed, the basket roller is unhooked so that the pipe joint being cut off can drop without catching this part of the machine and thus cause damage.

There seems to be a great possibility that many companies will take up and relay many miles of pipe lines in the next few years. Some of these will be old welded lines, while others will be the screw-coupled type of line; in any event, the cutting machine can show a great saving in taking up and relaying lines to be relaid by the welded process.

A number of companies have second-hand collar and thread pipe in their yards and are contemplating beveling such pipe, so as to place it in service. A machine has been recently developed for yard and shop work, cutting, trimming and beveling the ends of pipe for welding. Although it is designed for cutting lines where a single cut is to be made at a time, the machine is made rigid and capable of withstanding pipe line abuse the same as the double-beveling machine. The complete single-cut machine has a weight of about 20 lb. as compared with 60 lb. for the double-beveling unit, and has a size range from 6 to 12 inches.



Machine ready for double-bevel cut

Bearing Thermostat

FOR protecting motor-driven and other types of rotating machinery from breakdowns due to overheated bearings, The Electric Controller and Manufacturing Company, 2720 East 79th St., Cleveland, Ohio, announces the EC & M Bearing Thermostat. This is particularly well suited for use in connection with automatic pumping stations, motor-driven fans, automatic electric substations, conveyor systems, compressors, etc.

This bearing thermostat is of simple but sturdy construction and very compact. It consists of a sealed metallic bulb, containing a volatile liquid, that is connected, directly or through flexible copper tubing, to a one-piece seamless metal bellows. The electrical contacts are silver and are of double-break, quick-make and quick-break construc-

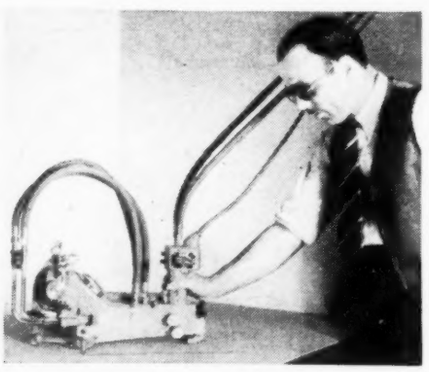
tion. A rise in temperature of the bearing of a rotating machine causes the volatile liquid to expand and generate pressure in the bulb. This pressure, in turn, is transmitted to the bellows, causing the contacts to open, thus shutting down the machine.

The thermostats are shipped to operate at 100 deg. centigrade. They can be adjusted in the field to operate at 15 per cent above or below this point.

Portable Cutting Machine

A PORTABLE cutting machine weighing but 43 lb. has been announced by The Linde Air Products Company, 30 East 42nd Street, New York, as an addition to its Oxweld line of apparatus. It is known as the Secator. Combining the portability of a blowpipe with the accuracy and finish of a cutting machine, the Secator makes it possible to do high-quality cutting anywhere in the shop or in the field.

Essentially it consists of an Oxweld Type C-14-H blowpipe (especially designed for it) mounted on an electrically-driven, air-cooled, dust-proof chashis. It is equipped with a direct-drive and runs either on a 1½-in. angle-iron



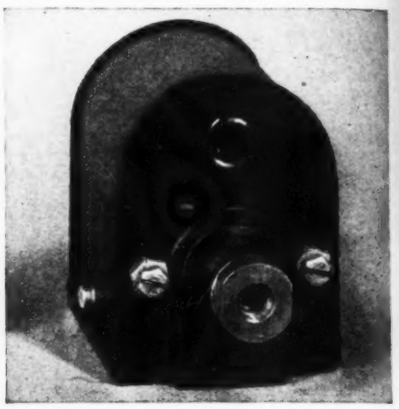
track, furnished with it, or on any relatively smooth plate. When operated on the track, it does straight-line cutting automatically. For cutting simple shapes it can be guided with a handgrip. For automatic circle-cutting, a center and radius rod are furnished. For convenience of control, the oxygen and acetylene valves are on the chassis rather than on the blowpipe. The blowpipe can be adjusted vertically and horizontally and also to cut bevels up to 45 degrees. Its cutting range is that of the C-14 blowpipe and the cuts are clean and smooth.

A universal motor that may be used on either 110- or 220-volt circuits operates the Secator.

Fluid Valve

THE Westinghouse Fluid Valve is an electrically-operated check valve recently developed by engineers of Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., for handling both large and small volumes of compressed air and liquid medium.

The valve is particularly well adapted to hazardous conditions where



it is desired to shut off the fluid flow from the prime mover instantaneously. For example, the coil of the valve may be inter-connected in the ignition circuit of any engine in such a way that cutting off the ignition switch will close the valve against the fuel supply.

Light-Duty Fast Coupling

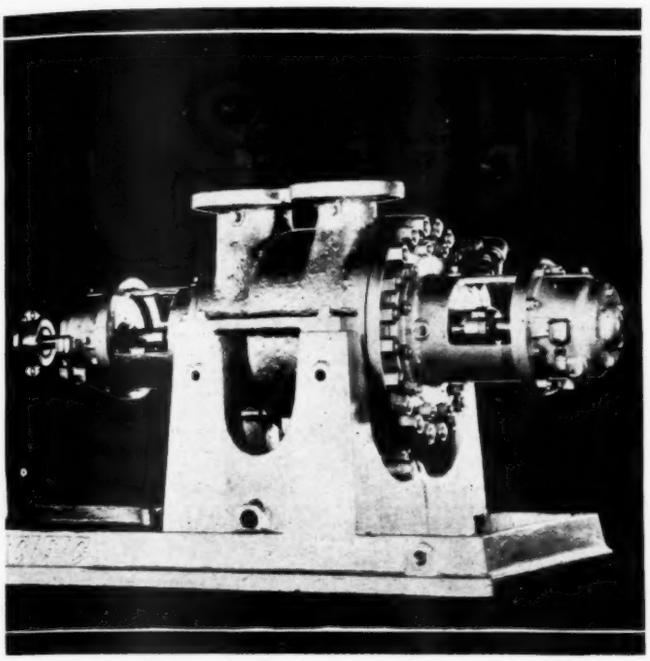
THERE is no better example of a careful and sure approach to a market, than the policy of The Bartlett Hayward Company before announcing the new light-duty Fast's Coupling.

The Fast's design, first used about a dozen years ago, introduced a revolutionary step in coupling practice. The use of external and internal gears, permanently in mesh, encased in an oil-filled casing, gave a new solution to the difficult problem of making couplings a permanent part of transmission machinery. The only drawback of the Fast design was the cost of manufacturing, when applied to small couplings. Forged hubs and forged casings to be machined, meant costs considerably above usual prices for the

THE SKF GALLERY OF DISTINGUISHED PERFORMANCE USERS:

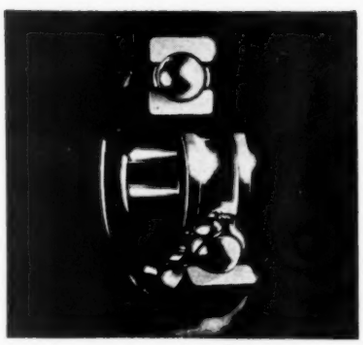
PACIFIC PUMP WORKS

24-HOUR SERVICE DEMANDS SKF BEARINGS



DEPENDABILITY

24-HOUR DUTY...that's the job this Pacific Horizontal Centrifugal Pump is up against in a large oil refinery, handling hot oil up to 700 degrees. Nothing can take the place of reliability here...it's not even thought of...for shutdowns cost money. And for this application...SKF Performance Takes Preference Over Price.



SKF Ball Bearings are used at each end of this two-stage Pacific pump operating at 3600 R. P. M. No danger of bearing failure at a critical time for rugged SKF's always run smoothly, are free from wear, need no adjustments and maintain close tolerances. Pacific knows that SKF's give satisfactory performance and will not fall down on the job... they've been using them for the past nine years.

SKF INDUSTRIES, Inc.
40 East 34th Street, New York, N. Y.

3120

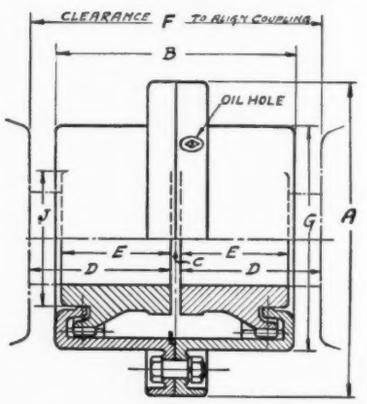
WHERE PERFORMANCE TAKES PREFERENCE OVER PRICE

●*You may buy a bearing as a bargain but try and get a bargain out of using it, for nothing is apt to cost so much as a bearing that cost so little*

SKF
BALL AND ROLLER BEARINGS

light-duty couplings from 1-in. to 2-in. shaft diameters.

To overcome this handicap, and still make Fast's design available for light-duty use at reasonable costs, experiments were undertaken to reduce forging and machining costs without sacrificing either performance or reliability.



All Dimensions are given in inches

SIZE NO.	MAX BORE	HP PER 100	MAX RPM	A	B	C	D	E	F	G	J	SHIPPING WEIGHT IN LBS.
1	1	2	3600	4 1/16	3 1/8	1/8	1 15/16	1 3/16	4	2 3/4	1 1/2	5 1/4
1 1/4	1 1/4	3.5	3600	5 1/8	3 1/2	1/8	2 7/32	1 11/16	4 9/16	3 1/4	1 3/8	7 1/4
1 1/2	1 1/2	6	3600	5 3/8	4 1/8	1/8	2 7/16	1 15/16	5	3 11/16	2 3/16	10 3/4
1 3/4	1 3/4	10	3600	6 7/16	4 5/8	1/8	2 13/16	2 3/16	5 3/4	4 1/4	2 9/16	15
2	2 1/8	15	3600	6 3/8	5 1/8	1/8	3 1/8	2 7/16	6 3/4	4 11/16	2 7/8	17 1/2

The die-caster was called in. Doehler Die Cast Metal was used; a zinc base with other alloys. Experiments soon demonstrated that by retaining the forged steel hubs, and using die cast sleeves or casings, perfect operating results and dependable performance could be obtained for sizes from 1 in. to 2⅛ in., horsepowers from 2 to 15 per 100 r.p.m. and a maximum speed of 3600 revolutions.

However, since its first manufacture, The Bartlett Hayward Company had been guaranteeing Fast's Couplings "for the life of the connected machines." Could they extend this blanket guarantee to these new couplings with die-cast sleeves?

Wisely, they determined that the guarantee could not be applied until after operating tests in enough installations to make the results final and conclusive. With the coöperation of several customers, more than 1000 of these new couplings were put to work. The couplings were installed on applications covering varieties of types, sizes and conditions of operations. For three years, this large list of actual installations was watched. It was conclusively demonstrated that the performance was so satisfactory that they could cover the new coupling with the same broad guarantee (for rated horsepowers and speeds), as applied to the standard forged steel couplings.

By persevering and testing, this manufacturer has made available a design, in the light-duty field, where heretofore it has been mainly thought of for heavy-duty application. The Fast's principle of "no flexible materials" is now available for small operation at reasonable cost.

These new light-duty couplings are now on the market, in warehouse stocks on the Pacific Coast as well as in the East.

Slush Pump Liners

GREATER resistance to scoring and wear, with consequent longer life to liners and pistons, is said to be one of many advantages embodied in Red Devil Slush Pump Liners, manufactured by the Oil Well Manufacturing Corporation of Los Angeles, Calif.

These slush pump liners are made of Kaloy, an electric furnace special abrasion-resisting alloy. Longer life and

greater pump efficiency have resulted from the use of these liners by many large operators, the manufacturers claim.

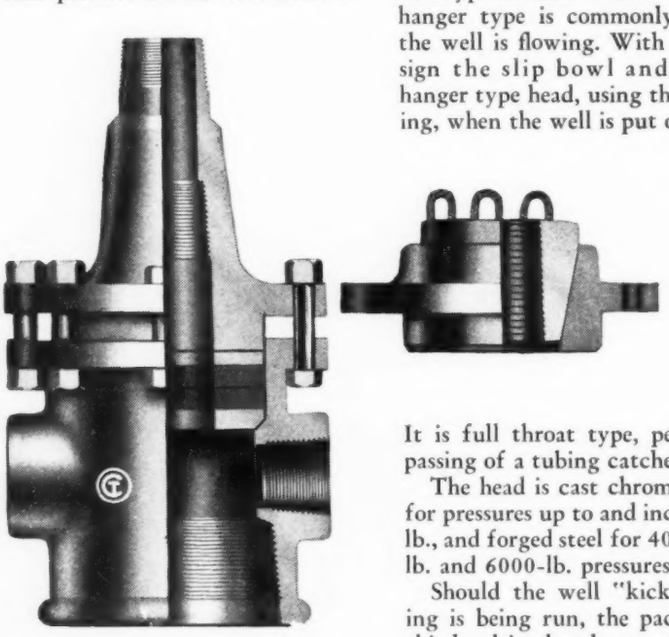
Red Devil slush pump liners are furnished heat-treated to a Brinnel hardness of more than 500, or not heat-treated to a Brinnel hardness of more than 230, according to the requirements of the operator.

Red Devil slush pump liners are made in suitable lengths for all types of pistons and for any size or make of pump. Literature illustrating and describing these liners is available, together with prices, from the manufacturer at 6000 South Alameda St., Los Angeles.

Tubing Head

OIL CENTER TOOL COMPANY of Houston, Texas, has brought to the market a new design of tubing head that permits the conversion of a flowing well to a pumping well without a complete change of the tubing head. This combination allows the hanging of tubing on either slips or threads. The new design results from a change in the design of the company's hanger type tubing head.

Parts on hanger type and slip suspension type are now interchangeable. The hanger type is commonly used when the well is flowing. With the new design the slip bowl and slips fit the hanger type head, using the same packing, when the well is put on the pump.



It is full throat type, permitting the passing of a tubing catcher.

The head is cast chrome nickel steel for pressures up to and including 3000-lb., and forged steel for 4000-lb., 5000-lb. and 6000-lb. pressures.

Should the well "kick" when tubing is being run, the packing unit of this head is placed around tubing, under collar, and tubing is lowered, its weight compressing rubber packing and effecting a seal, thereby acting as an added safety factor against dangerous pressures.

Electric Power

. . . for the Petroleum Industry

When you purchase electric power, whether for pumping oil from a well or for pipe line pumping, you are purchasing efficiency and dependability in your operations.

Multiple rated motors available today operate under a wide range of loads without any sacrifice of efficiency or economy and provide the utmost in flexibility.

Wells pumped by electric power can be accurately counterbalanced with a minimum of trouble, expense and delay. Operating records can be taken by the field man to check the efficiency of the well operation. Changing well conditions can thus be followed and provided for.

Electric power is instantly available at any hour of the day or night and is not adversely affected by hot or cold weather. Electric power is highly adaptable to the automatic operation of wells, whether pumping continuously or pumping intermittently on schedule, to give an exceedingly low lifting cost. This is especially an advantageous feature in the operation of wells in swampy areas, or in areas made inaccessible by heavy rains or other climatic conditions.

Salvage value of electric equipment is high and depreciation costs are low. Electric power has all the advantages that a field man appreciates—cleanliness, availability and minimum of attention—all factors that make for low maintenance costs.

TEXAS
POWER & LIGHT COMPANY

Safe Operation of Large Motor Truck Fleets

By CHARLES S. ZACK

Study of accident records may determine various remedies

THE safe operation of the largest fleet of trucks and passenger cars in New Jersey—that of the Standard Oil Company—includes more than lecturing its drivers on safety. At the central repair shop in Newark, N. J., Standard Oil has a complete laboratory where every known safety device is tested by machinery before adoption as equipment on trucks and cars in service.

J. F. Winchester, general superintendent of motor equipment for the Standard Oil Company of New Jersey, has charge of the 500 trucks and 200 passengers in the state and supervises the tests made for the safe operation of the fleet. The control of the fleet is centralized and the responsibility placed in two ways: maintenance with the automotive department, including the checking of output and installation, while the actual operation on the roads is under the sales department.

Standard operates practically every make of truck and passenger car, for, in addition to experimenting on types of appliances, it also experiments on original equipment and keeps pace with the changing trends in the industry.

Under observation in the central repair shop are different types of brake linings, washing machines, spark plugs, grease guns, battery chargers, etc. Motors taken out of trucks for repair are tested out in the shop before being put back. In fact, everything possible is being done there to eliminate guesswork and to make the fleet safe as far as it is humanly possible.

Discussing safety, Mr. Winchester says that all motor vehicle operators for Standard must have passed certain physical qualifications and have shown mental ability before being permitted to operate a company vehicle because "more than 85 per cent of our operators are actual salesmen and must show ability along this line, which, incidentally, requires constant mental alertness. The results of this rigidness are shown when our accidents are compared with those of the nation. Figured on a percentage basis of the total number of accidents, ours are less.

"The outstanding factor in the alarming growth of the traffic accident problem is the development of the motor vehicle and its more intensive and extensive utilization. This point directly applies to our organization, as we are constantly devising methods of speeding up the delivery of our products by applying the latest developments and technicalities of the automotive world. The territories covered are being expanded, giving a more extensive field that, in turn, makes more intensive operations necessary. As a result, some of our equipment, especially units hauling our products from bulk station or refinery to bulk station, are in almost constant operation.

"An accident always means that something is wrong. The chief reasons for reporting and studying accidents is to find out what is wrong and then applying the proper remedy. In view of the high total cost of accidents, it is a good investment to spend a moderate amount in collecting information and studying it in every possible way to determine how the various remedies are working or to ascertain what others may be needed. If, on the other hand, records are simply piled up in a filing case or tabulated in an annual report leading to no practical conclusions, the cost of collecting them is wasted. To develop the proper remedy for any ill a requisite is to know the type and extent of the disease. To check the mounting toll of traffic casualties, the available data must first be analyzed. What is the trend? Why is it? That is, what are the principal causes? And then, what is going to be done about it?

"The principal thought to be unceasingly considered is 'carefulness,' for that is the keyword to accident prevention. One must be careful when a project is in its initial stages, merely a thought to see that it is going to be started correctly, and then, when it is started, to see that everything is progressing accurately and efficiently.

"A motor vehicle is one excellent example. Before starting a careful operator will consider and, if possible, verify his beliefs whether the brakes are in good condition, lights and horn are passable and any other point that is necessary for the safe acting of the vehicle to be driven. After having started, it is then necessary to continue with watchfulness to a more attentive degree, as at an unsuspecting moment it may be necessary to bring any one or more or these devices into instant use, and they must perform their duty.

"Figures indicate that more than 50 per cent of the accidents occur at street intersections. Here we acquire the knowledge of just where safety principles and activities should be centered. In order to learn further just what should be done, we learn the most common causes of accidents. Motor vehicle operators not having the right of way and operators of other vehicles driving on wrong side of the road—cutting in—failure to signal, exceeding speed limit, are the actions causing the larger part of the total number of accidents; in fact, the aggregate percentage is 79. These are the types of accidents happening more frequently, although in order to arrive at a truer picture, it is necessary to apply the information learned to each individual locality, and then utilize the necessary safety principles.

"Similar to the great national problem, our company has one that to us is just as important, for along with the objective of the prevention of life and property damage, we have the great significant point, that of maintaining good will of the public. For one person's feelings that are directly injured there are his associates who, through his influence, are indirectly brought into the picture. It is then absolutely necessary that the public be given a square deal and in all probability even more, in order to warrant the continuation or securing of a customer's business. One of the methods of doing this is in the prevention of accidents.

"Summed up by three words that adequately cover the accident ground we have: Education — Engineering — Enforcement.

"Education is taken care of by the issuance of pamphlets, reminders, instructions and meetings where much stress is laid on the careful handling of equipment. Education is made more impressive by experience, which, unfortunately, many times, is a sad method of gaining knowledge.

"Engineering—We have safety and automotive engineers and keen managers who are making a constant study of the

predominating conditions and, incidentally, are doing marvelous work toward accident prevention. New safety appliances are experimented with to determine their usefulness in operation, and, if approved, immediately put in use.

"Enforcement is brought about by just that same term, the enforcement of all instructions to the point of even releasing an employe from service if an accident was caused by his direct carelessness. Lesser penalties are supplied for lesser forms of breaking discipline, although all are serious enough to make a decided impression on the one committing the act."

The motor vehicle service inspection report includes a careful check on each unit in the fleet, and is signed by both the driver and the inspector. It contains a space for recommended improvements. The inspector not only looks over each vehicle under his jurisdiction, but makes all running inspections himself. The general route superintendent checks the inspector's work and has the ability to analyze and the authority to report to the general manager to change vehicles from one location to another. Before Standard installs a vehicle it makes a complete detailed study of routes and what it costs to do business under previous types. Then it checks the vehicle itself as to design and whether it should function properly when installed. State laws must also be examined, because certain equipment allowed in one state is illegal in another.

Standard of New Jersey spends approximately $400,000 a year on repairs. This does not include money spent for testing equipment, such as brake testers and wheel aligners. There are also device testers, duplicates of those used by the Bureau of Standards in Washington. The central shop contains electrical, welding, paint, blacksmith and parts departments.

Pure Oil Company Refinery Executives Meet

THE photograph below was taken when for the first time in the history of the Pure Oil Company, all refinery superintendents were assembled in one place and had an opportunity of meeting each other and becoming acquainted. The occasion for the meeting was brought about by the apparent advisability of informing the superintendents on the latest steps the company had taken in improving the quality of its entire line of products. The scene of the meeting was the company's Chicago, Ill., offices.

Left to right, seated: A. E. Harnsberger, chief maintenance engineer; O. B. Wendeln, superintendent of Toledo, Ohio, refinery; R. L. Vernor, superintendent of Smiths Bluff, Texas, refinery; Rawleigh Warner, vice-president and treasurer; H. M. Dawes, president; C. B. Watson, vice-president; R. E. Young, manager of Oklahoma refining division; R. C. Osterstrom, executive assistant.

Standing, left to right: E. A. McCadden, superintendent of Marcus Hook, Pa., refinery; C. R. Wagner, chief chemist; D. E. Sullivan, chief construction engineer; J. P. Lanfitt, assistant distillation engineer; J. S. Stubbs, manager of personnel department; R. D. McClaran, manager of Ohio refining division; J. R. Palmer, superintendent of Cabin Creek, W. Va., refinery; C. M. Ridgeway, superintendent of Midland, Mich., refinery; E. E. McPherson, superintendent of Heath, Ohio, refiinery; Munger Ball, president of the Sabine Transportation Company, and G. A. McBridge, superintendent of the Muskogee, Okla., refinery.

Leaders and only exclusive rod manufacturers for 40 years.

●

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PULL RODS
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Rods to Meet All Conditions

●

Jones' Developments Are Usually Followed

The S.M. JONES CO., Toledo, O.
19 Rector Street, New York City, N. Y.
McBirney Building, Tulsa, Oklahoma

Carbide and Carbon Chemicals Corporation Awarded Achievement Trophy

The first award for chemical engineering achievement to be given to a company rather than to an individual goes to the Carbide and Carbon Chemicals Corporation, according to an announcement made today by Sidney D. Kirkpatrick, secretary of the award committee. The purpose of the award is to give public recognition to the company in the chemical industries that through the effective use of chemical engineering in any phase of its activity has contributed the most meritorious advances to the industry and profession since 1930, or during the past three years of the depression. The idea for this particular award was sponsored and launched last May by the publication *Chemical and Metallurgical Engineering*.

In the consideration of the Carbide and Carbon Chemicals Corporation by the committee on award, it was stated by Mr. Kirkpatrick, secretary of the committee, that the following facts were taken into account:

"Carbide and Carbon Chemicals Corporation is peculiarly a chemical engineering enterprise. It has had from the outset the financial and commercial backing of the Union Carbide and Carbon Corporation, but within itself it has been at all times planned, organized and managed by men who in fact if not always in name are chemical engineers. Perhaps no other maker and marketer of chemicals in America is so outstandingly pure chemical engineering in concept and operation. The plant of this company is known to be one of the outstanding examples of the chemical engineering arts of America.

"The achievements of the Carbide and Carbon Chemicals Corporation, either first undertaken or realized on a full commercial scale since January, 1930, are of three general types:

"The manufacture on an extensive commercial scale by direct synthetic methods of chemicals previously not available except from fermentation, destructive distillation, or other like non-synthetic processes. Outstanding examples of these are acetone, methanol, ethyl alcohol and ethyl ether.

"The production of new synthetic chemicals on a commercial scale, including tank car shipments, which chemicals previously have not been available for industrial usage because of the limited quantities which could be had. Among those that have been first produced during the depression are several of the propylene series, triethanolamine, ethylene chlorhydrin (in anhydrous form), numerous higher ketones and several new chlorinated hydro-carbon derivatives."

The award, which consists of an appropriate bronze plaque suitably engraved, will be presented on December 9th at the National Exhibition of Chemical Industries in the Grand Central Palace.

CORRECTION

Wayne C. Edmister calls the attention of our readers to an error in his chart that appeared on page 35 of last month's issue. On the specific heat scale, C should equal 0.4 to 1.4 reading from top to bottom, instead of 1.4 to 0.4 as shown.

International Oil Exposition to Be Held in 1934

It has been definitely decided that the International Petroleum Exposition will be resumed in Tulsa in the late spring of 1934, probably in May. Directors of the Exposition meeting with manufacturers and distributors of oil field equipment at Hotel Tulsa, Tulsa, Okla., on November 10, unanimously voted to hold the show, which will be the first since October, 1930. The date of the exposition and completion of preliminary arrangements were left optional with the board of directors. According to present plans it will be held in conjunction with the annual meeting of the Natural Gasoline Manufacturers' Association.

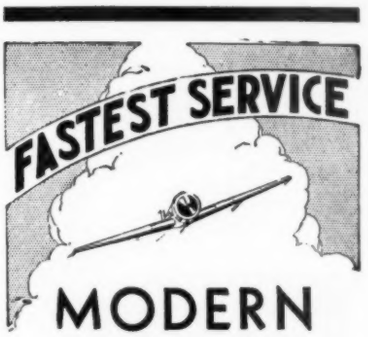
Optimism in oil circles, due to the continued stabilization of the industry through governmental agencies, reflected itself at the meeting, attended by approximately 75 persons actively identified with some phase of the petroleum industry. Every person who addressed the session favored the holding of the exposition and voiced belief in the future of the oil business. The strong sentiment prevailing in favor of a Tulsa oil show next spring was shown by the unanimous vote cast, which is the first such action taken since the exposition program was launched some ten years ago.

During the past three years equipment manufacturers have made many changes in the designs of their products and the Tulsa show will afford them an opportunity of displaying these improved products to the largest possible number of oil men within a short period of time. With this feature in view, as well as a general feeling of optimism, a large number of executives of oil field equipment concerns, including some of the majors, have already agreed to exhibit at the show.

Petroleum Electric Power Club Holds Fifth Annual Conference

The Petroleum Electric Power Club's fifth annual conference was held at the Oklahoma-Biltmore Hotel, Oklahoma City, Okla., on November 16, 17 and 18. The first day's program was devoted to matters of special interest to the petroleum industry and was attended by many persons associated with the Power Club.

Among the speakers at the various sessions were: D. C. McKee, the Empire District Electric Co., Joplin, Mo.; J. F. Owens, president, Oklahoma Gas and Electric Co.; D. J. Moran, president, Continental Oil Company; C. O. Shirley, president of the Petroleum Industry Electrical Association and superintendent of telephone and telegraph departments, Phillips Petroleum Company, Bartlesville, Okla.; W. H. Steuve, chairman, Edison Electric Institute Committee on Oil and Gas Pipe Line Pumping and in charge of oil industry sales for the Oklahoma Gas and Electric Company; L. T. Gibbs, Phillips Petroleum Company, Bartlesville, Okla.; Edwin Vennard, Southwestern Gas and Electric Company, Shreveport, La.; A. R. Watson, Gulf States Utilities Company, Beaumont, Texas; George Prout, General Electric Company, Dallas, Tex.; D. M. McCarger, Allis-Chalmers Manufacturing Company, Tulsa; and M. B. Wyman, Westinghouse Electric and Manufacturing Company, St. Louis, Missouri.



MODERN BUSINESS DEMANDS SPEED

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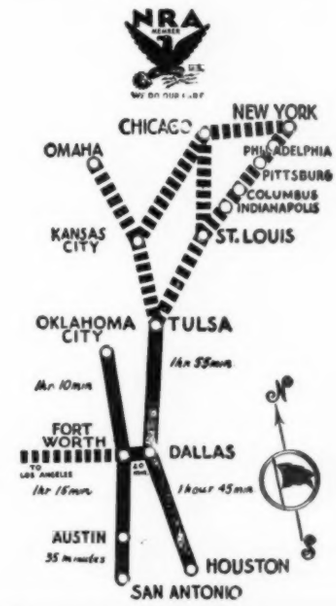
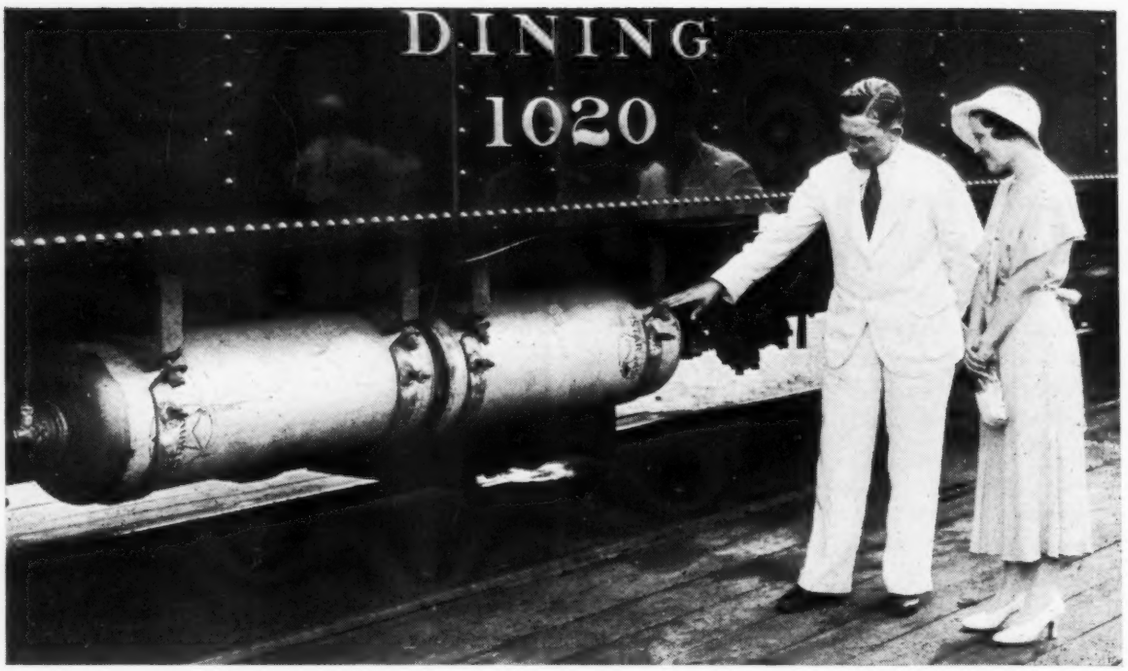


Bowen Air Lines



J. W. Martin, sales manager of the Stargas Division of Lone Star Gas Company, explaining how natural gas is carried on dining cars

Railway Diner Uses Natural Gas for Cooking

RECENTLY, the first dining car in the world to be equipped with natural gas for cooking purposes made an initial trip from Fort Worth to Longview, Texas, and return over the Texas and Pacific Railroad. No matter now whether Texans travel or stay at home the convenience of natural gas, a home product, goes right along with them; for the Stargas division of the Lone Star Gas Company, Dallas, has taken another forward step by giving the railway traveling public natural gas. This means: no cinders, ashes or smoke, no shoveling of coal or charcoal, much less heat in the kitchen and more uniform cooking.

Strapped to the undercarriage of the diner in a horizontal position are two green-head Stargas tanks. By locating the drums beneath the car no room is sacrificed within the diner and by placing them in a horizontal position ample clearance is provided for passing over any object that might likely be found lying along the railroad tracks. The accompanying illustration shows how these tanks have been attached to the railroad car. When in operation the two tanks and fittings are protected by shields that fasten over them.

Every known type of automatic device is incorporated in their design to insure positive automatic operation and regulation, even to an automatic turn-off that instantly shuts off the gas supply from the drums in an emergency. No matter what may be wrong, the gas supply ceases the moment anything abnormal occurs. An automatic switch-over device changes the flow line from one tank, when it becomes empty, to the reserve drum—even when the train is in motion. This automatic switch-over is a double regulator.

Equipment in the diner kitchen consists of a gas-fired cooking range, an instantaneous water heater, a griddle, coffee and hot water urns, and a steam table. Just as the most modern gas appliances function normally in a home kitchen or a hotel cafe, so do these appliances function in the diner. On the initial trip, 54 passengers were served quickly and with ease.

It was a dramatic moment when, after three years of experimentation and hard work, Asa Hunt of the Stargas division and E. L. Durning, salesman for the Dallas Gas Company, climbed abroad the diner to observe results on the initial trip. Anxiously they watched the colored chef light his burners, oven and griddle and begin preparing the dinner for the evening. The train got under way, there was swaying and drafts, but never once did the blue blaze falter or waver.

The feature that interests the railroad officials more than any other is the fact that gas keeps down heat on air-cooled diners and accomplishes the greatest savings along that line. "For de fust time in 21 years cookin' for dis Texas and Pacific Railroad ah can stand in front ob my ovens," rejoiced Ned S. Mathis, colored chef.

This air-cooled and natural gas equipped diner is now running regularly between Fort Worth and Texarkana.

Frank Yount Dies Suddenly

A sudden heart attack on November 13, when he seemingly was in good health, proved fatal to Frank Yount, one of the South's leading oil men. He was president of the Yount-Lee Oil Company, the concern responsible for the second great Spindletop boom in 1925 and for the development of vast oil interests in the Gulf Coast and East Texas areas. His success in the oil business enabled him to amass one of the largest fortunes in Texas, if not in the South.

Frank Yount rose to his position of wealth from the life of a mechanic and common laborer in the oil fields. In his later years he had taken up many hobbies that made him known throughout the nation. He gave the city of Beaumont some incomparable collections of violins and books, many valuable first editions, and made Beaumont known as the home of the Spindletop stables.

He was born on a farm near Monticello, Arkansas, and because of the early death of his father, when young Yount was but nine years of age, he acquired but little schooling. In his early years in the oil business he invented several special devices and improvements for the rotary drilling apparatus, some of which are still in use. His first oil company was organized with a capital stock of $5000 and in 1913 he bought out all interests. He operated as the Yount Oil Company until 1915, when he reorganized and took as a partner T. P. Lee of Houston, Texas.

The well that proved the vastness of the Spindletop field was his third there. It was this well that made Yount and remade Spindletop. This oil boom was a one-man proposition, for Yount had all the desirable leases in his safe.

Mr. Yount never forgot the time when he labored on the rig floor and each Christmas saw him remembering the men employed by him. Once he is said to have given his workmen $20,000 and so that they might get some permanent benefit out of his gift, he threw in a pair of fine leather boots for each man. This was done quietly as he was never a man to care for the limelight.

Struthers-Wells Titusville Announce New Representative

O. E. Berg, with offices in the Gulf Building, Houston, Texas, has been appointed sales representative in the states of Oklahoma, Louisiana and eastern part of Texas for the Struthers-Wells division of the Struthers-Wells Titusville Corporation, Warren, Penn., and will handle the sale of its pressure vessels, oil refinery and chemical process equipment.

Bridgeport Opens Houston Branch

The Bridgeport Machine Company has opened a new branch store at Houston, Texas, located on the corner of Quitman and West streets on the main highway to Kilgore, Lufkin and Shreveport. The company has maintained representatives in Houston and the near-by oil fields for several years and now this new store and warehouse will serve as a centrally located stock point for the surrounding territory and as a distributing center for East Texas and Gulf Coast branches.

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to fit every condition

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By WARREN L. BAKER

Alarm System Protects Domestic Users in Small Communities From Changing Gas Line Pressures

[Lone Star Men Devise Simple, Inexpensive Protective Device]

DOMESTIC consumers in small communities where the Lone Star Gas Company distributes natural gas are protected from the dangers of varying line pressures by the installation of pressure alarm systems. These alarms are set so as to warn the district foreman or the agent of changes in the amount of pressure so that he may make adjustments before there are any serious consequences. We all know that if the pressure on low-pressure lines becomes too great or too low that the flame in our stoves may be extinguished and that consequently there is a danger of gas escaping into the rooms. The dangers of such occurrences in more than 100 communities on the Lone Star system have been eliminated by the installation of simple, inexpensive alarm systems. The value of such warning systems have long been recognized and the majority of natural gas main lines are equipped with different types that are on the market, but heretofore the expense of such installations have prohibited their use in communities where the sale of gas has been only in small quantities. The Lone Star method of protecting its consumers in such districts does not exceed in cost $11 per installation.

The company uses three systems, namely, the low-pressure type, the high-pressure type and the combination type. All three are designed to meet specific distribution conditions in different communities. Each system depends upon an electric fuse box and the forming of a circuit to ring the bell whenever the gas pressure declines or rises to a predetermined point.

The low-pressure instrument consists of an ordinary manometer, filled with mercury, attached to the gas line. At the top of the manometer are two adjustable set screws, one on each side. One of these screws is set to register the desired amount of high pressure and the other the low pressure. Whenever the pressure in the gas causes the mercury, which is an electric conductor, to make contact with either one of these screws an electric circuit is formed that rings a bell. Adjustments to the set screws can be made easily to register any desired pressure in ounces and the alarm bell may be set at any location. The bell is frequently installed in the foreman's or the agent's home, where there is likely to be someone about at all times.

The high-pressure type is designed to be installed where the gas pressure may be registered in pounds. It consists of an inexpensive spring gauge, the glass face of which has been removed. At two determined points around the outer edge of the dial two small strips of brass are placed. The brass is insulated so that there is no danger of the metal ring around the dial face causing a short in the circuit. One of these strips of brass is attached to the dial at the highest desired point of pressure and the other at the lowest desired point of pressure. Cat-whiskers have been extended over the face of the dial at points where the brass strips are, and whenever the hand on the gauge dial reaches one of these points it forms a contact with the cat-whiskers to complete an electric bell circuit. The bell on these installations are set to ring constantly, regardless of whether the pressure later rises or decreases, until the attendant has unscrewed a plug in the fuse-box. This system of manual operation was decided upon to be certain that someone heard the bell, otherwise it might ring only at the point of contact and then stop while the pressure kept on rising. If the attendant did not happen to hear it when at the point of contact the danger might become very acute.

In the combination system the two types of gauges are mounted on a common box.

These instruments are periodically tested to make sure that they are in proper working condition.

This idea can be applied very advantageously to many conditions encountered in the oil and gas industry. For example, in addition to the use being made of it by the Lone Star, such a system could be installed on lines servicing lease houses and the like.

A. P. I. to Hold 1934 Meetings in Dallas and Pittsburgh

The fifteenth annual meeting of the American Petroleum Institute will be held November 12th to 15th, 1934, at Dallas, Texas. The Institute formally accepted the invitation of Dallas oil men to hold their convention in that city during 1934. The directors of the A.P.I. also have voted that the midyear meeting, which has been held in Tulsa, will next year go to Pittsburgh, Pennsylvania. The exact dates for this meeting are to be announced later, but they will be in May or early June.

Skelly Oil to Build Natural Gasoline Plant in Kansas

The Skelly Oil Company has announced that it is to construct immediately a combination absorption well-pressure gasoline and booster station on its Cunningham lease near that city in Kingman County, south central Kansas.

The gasoline will be supplied with gas from 11 producing wells, which will shortly be increased by the completion of several now drilling. The residue gas from the plant will be boosted into the line of the Northern Natural Gas Company and will find a market in the North.

The plant will be built by its own gasoline construction department, and will consist of direct-driven Cooper-Bessemer compressors capable of handling 6,000,000 cu. ft. of gas a day. The plant will be operated on a well-pressure of 35 lb., while at the wells it will vary from 40 to 50 pounds.

National Drilling Contractors' Association Organized

Michael J. Delaney, president of the Texas, Louisiana, and New Mexico Drilling Contractors' Association, Dallas, Texas, was chosen president of the National Drilling Association, formed in Chicago during the American Petroleum Institute Convention. Thomas D. Phillips, Mead & Phillips Drilling Company, Tulsa, was elected executive secretary-treasurer. He is also secretary-treasurer of the Oklahoma-Kansas Drilling Contractors' Association.

Presidents of all state drilling associations automatically become members of the directorate of the national organization.

New Gasoline Plant for West Virginia

Henaghan & Hanlon, Inc., with offices in Tulsa, Okla., and Sistersville, W. Va., has started construction of a natural gasoline plant in Richey County, West Virginia, to extract gasoline from gas produced in the new Lost Run pool. The plant will be of 5,000,000 cu. ft. capacity with provisions for additions if field developments justify. The gasoline produced will be run to the company's central stabilizing and treating plant at Cornwallis, W. Va., and loaded out in conjunction with production from the concern's several plants in Richey and Pleasants counties.

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On all of the 39 stations of the Great Lakes Pipe Line, RIDGID Pipe Wrenches are standard equipment. The set of each station consists of 3 wrenches: one 36-inch, one 18-inch and one 12-inch.

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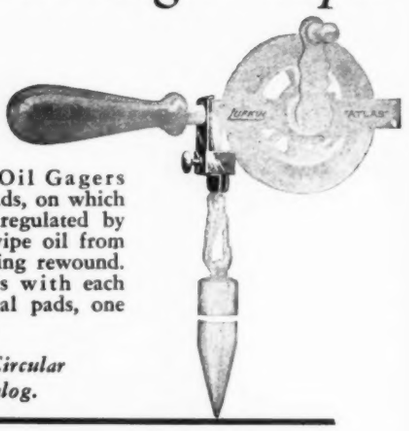

This strong compact wiper is designed to fit *all* LUFKIN Oil Gagers Tapes. Small pads, on which the tension is regulated by thumb screw, wipe oil from line as it is being rewound. Six extra pads with each wiper; additional pads, one dozen in a box.

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Tomball Field Given Third Outlet

Stanolind Pipe Line Company has completed its 4-in. carrier from the Tomball, Harris County, Texas, field to its main line and thus provides the new pool with its third outlet. The Stanolind Crude Oil Purchasing Company has posted a price of $1.15 per barrel for crude oil purchased in the area. This is the same price being paid by Humble Oil & Refining Company and Magnolia Petroleum Company, which own and operate the two other transportation facilities from Tomball.

Stanolind's trunk line through the district extends south from Mexia to the Houston ship chanel and a recently built extension from that point by Pan-American Pipe Line Company, an affiliate, will supply the Pan-American Refining Corporation's plant under construction at Texas City with crude oil.

Oberfell Named NRA Adviser

George G. Oberfell, president of Philgas Company and vice-president and director of the Phillips Petroleum Company, Bartlesville, Oklahoma, has been appointed labor and industrial adviser of the liquefied gas industry by the National Recovery Administration.

Seven New Tanks Built at Houston

Seven new 93,000-bbl. capacity tanks provide additional storage facilities for the Sinclair Refining Company at its Houston, Texas, plant. These tanks are 120 ft. in diameter, 46 ft. 4 in. high and are arch-welded throughout.

The sides of the tanks are butt-welded. The plates were made flush on the inside to form a cylinder of uniform diameter from top to bottom, a condition very desirable for the efficient operation of floating roofs. All tanks are equipped with Wiggins floating roofs. The roofs, as well as the bottoms, are lap-welded.

These tanks, which add 651,000-bbl. capacity to Sinclair facilities, were built by The Chicago Bridge and Iron Works using Fleetweld electrodes and machines manufactured by The Lincoln Electric Company.

Charles E. Thayer Succumbs

Charles E. Thayer, sales manager for the Gustin-Bacon Manufacturing Company for the last 25 years, died on October 26 at Tulsa, Oklahoma. His death was due to high blood pressure.

Mr. Thayer worked out of Kansas City, Mo., until about four months ago when he made Tulsa his headquarters. He was a well-known and popular member of the oil field supply industry. During his long service with the Gustin-Bacon Company, much of his time was spent in keeping contact with the petroleum industry and this association gave him many friends among oil men.

Petroleum Equipment Code Approved

President Roosevelt has approved a code of fair practices for the American petroleum equipment industry. The code was drafted by the American Petroleum Equipment Suppliers' Association, organized in Dallas last August. The approved regulations are but slightly changed from the original ones adopted at the Dallas session.

The code provides for a 40-hour week, averaged over a three-month period, with not more than 48 hours nor six days' work in any one week. Special exemption is made for men in official capacities, sales organization and research work who receive more than $35 per week. It is estimated that operation under the adopted regulations will add some 4000 new employees to the industry.

The association has the support of the majority of petroleum equipment manufacturers. Any person or company engaged in the manufacture or sales of equipment to the petroleum industry may become a member, and any member is privileged to tender his resignation at any time, provided all dues have been paid. W. L. Childs of the Reed Roller Bit Company, Houston, Texas, is president of the organization.

Valvoline Making Plant Improvements

The Valvoline Oil Company is remodeling its Butler, Pa., refinery. Work, which is now in progress, is expected to be completed in January, 1934.

The company has let a contract to Foster Wheeler Corporation for one 2500-bbl. crude oil distillation unit, one 2000-bbl. solution redistillation unit and one 700-bbl. waste-heat type special naphtha distillation unit. Additional improvements include new fullers-earth burners, four automatic canning machines, additional tankage and new "Q" compound and Ethyl blending plants.

CORRECTION

In our September issue it was stated that the Consumers Power Company had laid a 10-in. welded gas line from Midland to Saginaw, Michigan. We have been informed that this is a Dresser coupled line.

Alco and Kellogg to Sell Clay Processes

Gray Processes Corporation has appointed Alco Products Company and M. W. Kellogg Company exclusive sales agents for its three clay treating processes, the Gray, Osterstrom and Stratford.

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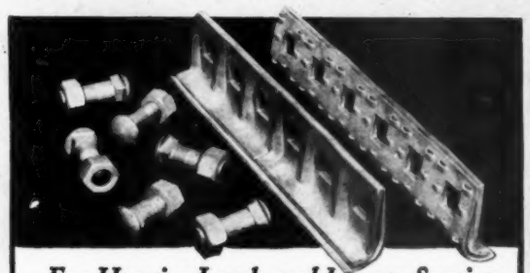

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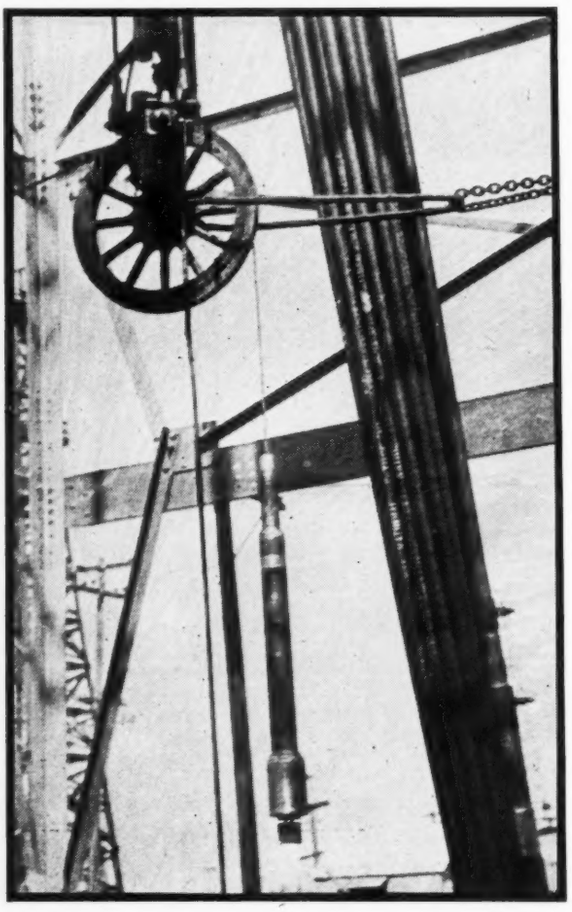

Bringing out the slip on the first run in with the magnet

THE continuous improvement in equipment combined with both more careful and more efficient drilling and production methods have done much to reduce the number of fishing jobs now being encountered in oil wells. In spite of all precautions, however, subsurface equipment will get lost or damaged in a hole and will have to be fished out. New fishing methods that cut down lost time or meet unusual conditions are therefore studied with interest; and probably the latest application of such a method was the use of a magnet to recover metal that was stuck in the casing in a way that prevented its recovery by mechanical means.

Every fishing job is its own particular problem and it is hard to conceive of some method or tool that will meet any and all fishing jobs that may occur. Hundreds of fishing tools with both general and specific application have been designed and are rendering adequate service. Acid has been used effectively to disintegrate metal to such a degree that it can easily be drilled up. The hydrostatic bailer has performed valuable service in cleaning out small pieces of junk and material that have hindered drilling to a serious extent. And many ingenious means and devices have been used to meet freak conditions that will probably never be duplicated.

In considering the magnet as a fishing tool, however, its more general application as indicated by its actual performance is of paramount importance. Naturally, only metal that can be magnetized can be taken out of a hole with it. A great many fishing jobs of any consequence, however, are caused by such metal and its recovery by tools or other mechanical means is often very difficult and attended with possible damage to the hole.

Probably the greatest advantage in using a magnet to bring metal up from the place where it is lodged in a hole is its speed and ease of operation combined with its adaptability for use in a well without the necessity of rigging up any equipment except that transported to the location on the truck in which the magnet and its equipment is carried. This is especially desirable for producing wells where fishing jobs occur while cleaning out or repairing the hole.

Magnets for fishing have been tried out in several instances during the past few years but it was not until quite recently that a magnetic device was perfected to meet the varying conditions that accompany a fishing job. Some of the magnets used relied upon batteries to supply the necessary electric current, while others carried current down the wells by means of wires. In fishing for the broken parts of a tubing catcher in Union Oil Company's well Copeland No. 21, Huntington Beach, Calif., however, a magnet designed by the Lane-Wells Company of Los Angeles demonstrated the advantage of running a magnet on a steel armored cable, which served both for supporting the magnet and for conducting the current to it.

The tubing catcher stuck at 3150 ft. above which was 1350 ft. of oil and water. It was in 6⅝-in. 26-lb. casing, which was cemented at approximately 3800 feet. The metal

Used to Recover Oil Well

By
WALLACE A. SAWDON
Petroleum Engineer
Los Angeles, California

A part of the recovered metal clinging to the magnet

was jammed in the hole so tightly that a spear could not be gotten through; and the fish could not be picked up with a grab. A lead impression block was run in and disclosed that a slip was lying loose over the hole.

The magnet equipment was transported to the well and five runs made. The first brought out the slip and during the next four runs three pieces of the tubing catcher body were extracted. The entire time consumed in rigging up, making the runs and dismantling was only three hours.

There are two important factors to consider in the design of a magnet that is to be run into an oil well, whether it is producing or drilling. The lines of force between the poles must be confined to the end of the magnet so that there will be no chance whatever of it sticking to the casing under any circumstances. And the device must be watertight under high pressure so that there will be no danger from leakage, even when run to the bottom of a deep well where the hydrostatic pressure due to a hole full of fluid may run up to 3000 lb. per sq. in. or even greater.

The simplicity of the design of the magnet used in the Union Oil Company well is of interest. The core is of soft iron, as is also the cylindrical shell that forms the other pole. The entire device is enclosed in a bronze shell, which confines the lines of force between the poles to the end of the magnet.

In building the magnet it is tested to 1500 lb., even before the core is inserted. Its watertight property under pressure is acquired by hermetically sealing the core within its enclosing case by electric welding.

Of great importance is the cable on which the magnet is run into the well. The one here used is a patented cable that has been run many times in deep wells and under high fluid pressure and temperature. It is reeled on a hoist mounted on the truck that transports the entire equipment to the well.

The truck is completely equipped with a D.C. generator set with control panel to supply energy for the magnet. In operation, from 100 to 150 volts of direct-current are used with an indicating device at the surface of the ground showing when contact with the fish is made.

It was interesting to note on the job here described that this indicator showed the fish was hit at the same instant that a weight indicator gave the same information. The electrical depth thus checked exactly with the mechanical depth. Moreover, if for any reason the fish gets dislodged from the magnet during its progress up the hole, the indicator will disclose the fact at the moment the metal leaves the magnet.

The capacity of the magnet is evident from its performances. The different sizes that are necessary for different diameter holes naturally do not have the same lifting capacity and are made in different lengths both to obtain the desired magnetic field and to give the weight necessary to run into a hole full of fluid. The four sizes now being made are: 3½-in. O.D., weight 150 lb., lifting capacity 450 lb.; 5-in. O.D., weight 200 lb., lifting capacity 635 lb.; 7-in. O.D., weight 215 lb., lifting capacity 950 lb.; and 9-in. O.D., with a lifting capacity of 1600 pounds.

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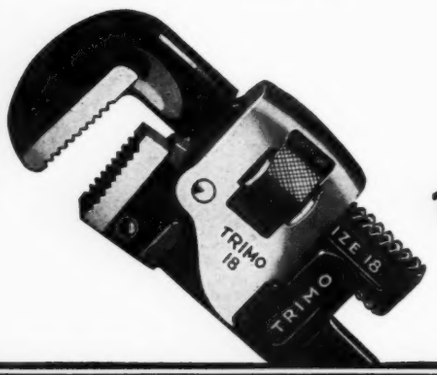

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BOOKS *of the* TRADE

THE BOOK OF STAINLESS STEELS. By Ernest T. Thum. The American Society for Steel Treating, 7016 Euclid Avenue, Cleveland, Ohio. 614 pages, 200 illustrations. Price $5.00.

Seventy-seven authorities on making and using the many kinds of heat and corrosion resisting chromium alloys collaborated to write this book under the editorship of Ernest E. Thum, editor of Metal Progress. Each man was selected to write a chapter for the book on his particular specialty in the field. The test is therefore authoritative.

About two-thirds of the chapters describe the properties of the steels—how to fabricate them and what to expect of them. Others tell of a multitude of successful applications.

The reader of this book need not be a highly trained metallurgist to profit from it, but even the most exacting technical man will find plenty of precise information.

* * *

AMERICAN SOCIETY FOR TESTING MATERIALS STANDARDS, 1933 issue. Copies of the book can be obtained from A. S. T. M. headquarters, 1315 Spruce Street, Philadelphia, Pa., at the following prices: either part, $7.50; both parts, $14.00.

This is a triennial publication containing all the standard specifications, methods of test, recommended practices and definitions formally adopted by the Society.

The 1933 issue of this publication is composed of two parts —Part I containing all A. S. T. M. standards covering metallic materials; Part II, all standards relating to non-metallic materials. Both parts aggregate 2300 pages.

In both parts of the book, the specifications for a particular class of material are given first, followed directly by the test methods, definitions, etc. A complete subject index is included in which each standard is indexed under the principal subject covered, keywords being given in alphabetical sequence. This index, together with two tables of contents, one listing standards by the materials covered, the other in order of numeric sequence of the designations greatly facilitates the use of the book.

* * *

MANUAL OF INDUSTRIAL CHEMISTRY. Edited by Allen Rogers. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York. Two volumes, 1542 pages. Price $13.00.

This book brings to you a great fund of the latest ideas and newest methods in their most usable form, together with a detailed account of each chemical industry. It gives a systematic knowledge of the present-day situation in each chemical field. It covers not only new processes but new products, new equipment and new methods of procedure in its 52 chapters.

TRADE LITERATURE

THERMOMETER AND PRESSURE GAUGE LINE. The Brown Instrument Company, Philadelphia, Pa., has published a new catalog featuring the new Brown Thermometer and Pressure Gauge line. The new Brown Thermometers and Pressure Gauges are available in indicating, recording and controlling types and have many new and improved features.

SINGLE CRANK (dual-stroke) OILBATH GEARED POWER. Oil Well Supply Company, Dallas, Texas, has issued bulletin No. 111 (733) descriptive of the Imperial No. 80-SC Oilbath Geared Power with Single Crank (dual-stroke). This bulletin includes a general description of the power, three photographs, a sectional drawing and an installation drawing.

LUBRICATED PLUG VALVES FOR OIL AND GAS WELL DRILLING is the topic of a new bulletin recently issued by the Merco Nordstrom Valve Company, subsidiary of the Pittsburgh Equitable Meter Company. This publication describes the application of these valves on boiler installations, steam, water and mud lines, blow-out preventers, Christmas trees and tank battery service. A section of this 20-page catalog is devoted to Timken Michigan "Screw Lift" Drilling Through and Master Control Plug Valves. Copies of the bulletin may be obtained by writing the company at 400 N. Lexington St., Pittsburgh, Pa.

FLUID VALVE of a new type is the subject of a four-page leaflet recently issued by the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. Large or small volumes of compressed air, liquid mediums such as gasoline, water, oil and gas can be controlled accurately by the use of this electrically operated check valve.

COMPENSATED PRESSURE CONTROL INSTRUMENTS. Mason-Neilan Regulator Company, Boston, Mass., has been distributing to the trade copies of a new bulletin known as No. 2000-c. It describes the construction and operation of Mason-Neilan Compensated Pressure Control Instruments. It is an illustrated 24-page booklet.

MACHINE TOOLS is the title of a new four-page circular issued by the Wagner Electric Corporation, St. Louis, Mo., profusely illustrated with honing, milling, drilling, reaming, tapping, threading, grinding and other machine tools, from the smallest to the largest sizes—all operated by Wagner totally-enclosed fan-cooled type CP motors.

FORTY YEARS IN DISTILLATION is the title of a beautiful book just issued by The Lummus Company, 50 Church Street, New York City. This publication is a review of the company's progress in the art of distillation over a period of 40 years. It is strikingly presented in an interesting and concise form, with many excellent photographs adding much to its value.

PHOTOELECTRIC RELAYS. Bulletin GEA-165A issued by the General Electric Company, Schenectady, N. Y., is fully descriptive of the use, application and design of the company's CR7505 Photoelectric relays.

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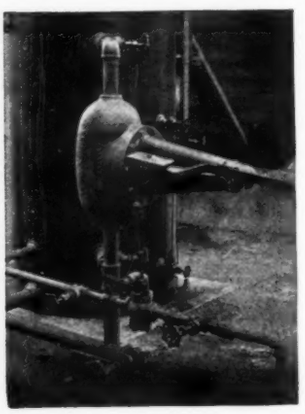

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